POWER PLANT ENGINEERING

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Contents of this Issue

Page

WITH THE EDITORS....322

SUGGESTIONS FOR PROFITABLE READING....323

SPRINGWELLS PUMPING STATION....324

KIPS BAY HIGH CAPACITY COAL PULVERIZERS. By Percy Cassidy....328

CAUSTIC ALKALINITY IN BOILER WATERS. By Reinhold F. Larson....329

CARE AND OPERATION OF EVAPORATORS....333

FEATURES OF NEW HUDSON AVENUE ADDITION....334

INDUCTION MOTOR OPERATION. By Edward W. Johnston....338

CONVERTIBLE TRACTOR SHOVELS AND CRANES. By C. E. Kohl..338

ALKALINITY DETERMINATION CHART. By Norbert W. Sager..339

PUMP ROTOR TROUBLE. By Grady H. Emerson....340

KEEPING AN OIL PIPE WARM. By George P. Pearce....341

VOLTAGE DROP CALCULATION CURVES. By Vernon W. Palen...342

ACCUMULATORS FOR HEAT STORAGE....343

COÖPERATION BETWEEN PRIVATE PLANTS AND THE UTILITIES—III. By O. H. Henschel....344

DIESEL ENGINE UPKEEP. By Edward J. Kunze....346

UNUSUAL POWER RECOVERY SYSTEM....348

READERS' CONFERENCE: CURVE FOR FINDING LOAD ON TRANSFORMERS. SAFEGUARDS FOR TRANSMISSION EQUIPMENT. ENGINE DRIVE FOR AUXILIARY APPARATUS. PORTABLE LIGHTING FIXTURE FOR FURNACE WORK. WHY THE GEYSER ACTION IN THE STEAM? SAMPLING POT FOR VACUUM. MEANS FOR SAMPLING OIL SHIPMENTS. READING GAGES AT HIGH ALTITUDES....349

PLANT OPERATION PROBLEMS: PUMP TROUBLES?—LET'S HAVE THEM. MOTOR OPERATION PROBLEMS. MOTOR DRIVE FOR ISOLATED MACHINES....353

X-RAY INSPECTION OUTFIT....354

MODEL 25 LUBRICATOR....354

4-WAY VALVES....355

AUTOMATIC COMBUSTION INDICATOR-RECORDER....355

LEVER OPERATED CONTROL VALVES....355

TIMING CONTROL FOR WELDING SERVICE....356

AUTOMATIC SOFTENING PROPORTIONER....356

PULVERIZED COAL UNIT....356

NEWS FROM THE FIELD....357

FOR THE ENGINEER'S LIBRARY....358

POWER PLANT CONSTRUCTION NEWS....360

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index, on file in public libraries.

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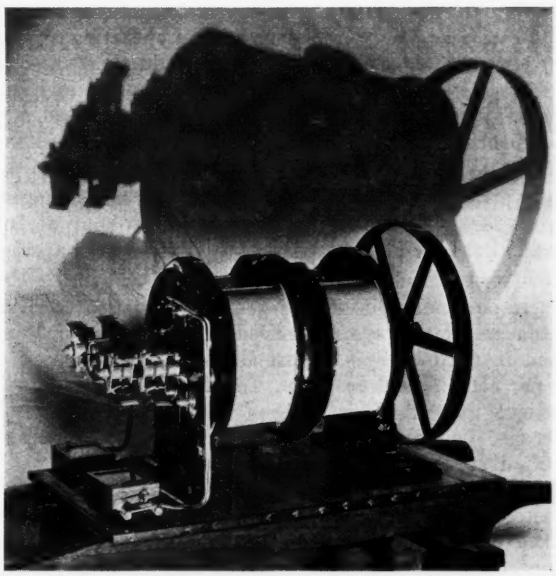


1633 Per Cent a Year

ENOUGH TO MAKE even a banker lick his chops and go out in a spirit of reckless philanthropy to buy an apple. Yet that represents the growth of generating unit sizes from 1883 when the above 2-kw. unit was patented to the present time when the largest single shaft unit is rated at 160,000 kw.

Called the Bane generator after its inventor, it was patented in 1883 and exhibited at an exposition in Louisville, Ky. It was seen there by Mr. Gaylor, general manager, and Mr. Hurst, operating engineer of the Louisville Electric Light Co., a predecessor of the Louisville Gas & Electric Co. and they purchased it.

Measuring 27 in. long, 17 in. high and 17 in. wide, weighing 150 lb. and rated at 2 kw. it was used by the company to furnish electricity for 12, 1200 candle power, 50-v. arc lights and was in service until the advent of the incandescent lamp.

It is now one of the units in the Ohio Falls Station at Louisville but no longer in service, having been retired to the security of a glass case where it can gaze with the aristocratic stare of one of the first families at the 10,000-kw. upstarts in the new plant.

Fifty years ago a 160,000-kw. unit was a dream no less fantastic than the Magic Carpet. Today they are a reality although still a matter of more than usual interest. One such unit is installed in the Hudson Avenue Extension described on page 334.

Each unit will have four boilers, each of which will make more than half a million pounds of steam per hour. The stokers, of a new type, are the largest in the world today. We say this with reservations because the way stokers have been growing, someone may decide to build one twice that size tomorrow.

WITH THE EDITORS

Station Costs

Important as thermal efficiency is in the power generating station, the item of fixed charges is certain to to play an increasingly important role in future design and construction. In a modern station operating around 50 per cent capacity factor, total production cost will be about evenly divided between fixed charges and fuel costs. With lower capacity factors, fixed charges may be 75 or 80 per cent of the total cost.

In the past, stations have cost from $60 to $120 per kilowatt of generating capacity with heat rates ranging from 24,000 to 12,500 B.t.u. per kilowatt-hour at full load. Perhaps $100 and 16,500 B.t.u. are fair average values.

Importance of fixed charges in reducing production costs are not always recognized. A reduction of 1 per cent in fixed charges is just as good as a reduction of 1 per cent in fuel economy. In fact, there is reason to believe that it is better than the reduced fuel costs because few, if any, stations operate any considerable period at 50 per cent capacity factor.

Over the lifetime of a station the average capacity factor may be down around 25 to 30 per cent where the fixed charges are perhaps down as much as the fuel charges. Higher capacity factors and fuel values justify more expensive stations but the so-called base load station has been shown to be largely a myth. Because of differences in load conditions, fuel costs and relative importance of uninterrupted service, it would be foolish to say that the spread from $60 to $120 could be eliminated.

Future progress will undoubtedly narrow this margin, however, tending to bring it closer to the lower value. One of the biggest factors in this lower trend is the use of single boiler per turbine unit, a practice introduced a few years ago at Bayside, used effectively at South Amboy recently and now being used on an 80,000-kw. unit now under construction at Port Washington.

With single boiler units capable of supplying an 80,000 or 100,000-kw. unit, boiler availability of 90 per cent or over, high boiler ratings, compact designs and more standardized practice, station costs are bound to decrease.

Furthermore a decided trend toward simplicity is evident. In the past many operating conveniences were installed which added nothing to the reliability of the station. Interconnection and increased reliability of equipment makes it possible to eliminate some of the elaborate protective features heretofore thought necessary to insure uninterrupted service.

In the past, every new station meant new and expensive designs. Now, pressures, unit sizes, auxiliary power supply and, to a certain extent, temperatures have been standardized. Five years ago a cost of $60 a kilowatt for a 1200-lb. station would have been considered nonsense; today it is considered possible; tomorrow we may be thinking of $50 stations.

The trend of costs is ever downward, not only in the generating but in the distributing systems as well. The future of the power station depends upon cheap and reliable industrial rates and the indications are that the decade upon which we have just embarked will be one of unprecedented growth, the result of diligent application of experience gained during the past ten years.

Household Power an Outcome of Unemployment

Changes in the industrial setup of this country are taking place. We can hardly expect that a great number of skilled, energetic, educated men will endure unemployment over a long period. They will do something by which it is possible to make a living for themselves and their families. Many men of high caliber and initiative are now becoming desperate in their endeavor to place themselves with established institutions and without capital are turning their minds and hands to any line of endeavor which will yield them an existence.

Among the results which have been noted are that one-man activities are multiplying rapidly throughout the country; skilled mechanics and engineers are occupying their time in perfecting patentable ideas and selling home-made gadgets by the door-to-door method; chemically minded men are making soaps, cosmetics, compounding lubricants and antiseptics; electroplating is becoming a basement and garage industry with neighbors for customers; farmers are marketing direct to consumer; garment workers are working at home for personally solicited customers; cabinet makers are repairing furniture for customers who would otherwise buy new furniture; hard pressed city dwellers are moving to acreages where they can raise poultry, vegetables and fruit for home consumption; tool makers are doing a house-to-house business in sharpening scissors, knives, chisels, saws; mechanics are repairing and adjusting all kinds of household appliances.

All of these activities are in direct competition with long-established manufacturing and marketing industries, a competition which is not only keenly felt but is almost certain to continue and grow as long as a high percentage of unemployment compels men out of their chosen line of endeavor.

Such activities do not pay large dividends, for the products must be sold to the consumer at a price that is an advantage to the consumer. In many cases, however, the profits of several middlemen are eliminated and the one-man industry can meet its competition in any way legally available without interference from outside.

One-man establishments are not new in the history of industrial development for many of our large present-day institutions started as a small foundry, blacksmith or machine shop and grew up under the guidance of an all around genius.

Under such conditions a growing need for household electric power has developed. Small motors, lathes, drills, sewing machines, washing machines and electrical appliances—any device which in any way can help a man make a living and is not exorbitant in price—will be the demand of the near future if large industrial concerns cannot find a way to absorb a large percentage of the present unemployed workmen.

Suggestions for Profitable Reading

160,000-Kw. Turbines Must Not Be Used in Airplanes

No matter how good your idea is, you cannot use such a turbine in an aircraft, because it is not licensed for such use. Now don't let anybody intimate that your desire to use a 160,000-kw. turbine in an airplane indicates some degree of mental unbalance. Why, fifteen years ago the very idea of a turbine of that size was considered the raving of a lunatic. So if you can only get the license . . . !

Fifteen years ago, as we stood in blank amazement before a 35,000-kw. turbine generator, they told us we were looking at what was probably the largest generating unit that could be built—you know, size of parts, limiting railway clearances and all that. The role of the prophet is always beset with difficulties and uncertainties, but never more so than in this case. Just a few weeks ago one of the ubiquitous editors of Power Plant Engineering got a kink in his neck gazing up at the new 160,000-kw. generating unit at Hudson Ave. and as he tried to straighten it out (his neck) he wondered what kind of an alibi the 35,000-kw. maximum boys could present today. Well, anyway, there it was—160,000 kw. all in one single generator. So whether you are familiar with the essential details of this new addition or not, it will be to your advantage to look over the article on the completed 160,000-kw. unit in this issue.

Water, Water, Everywhere!

It is a strange paradox that *homo sapiens* cannot now live for long periods on water yet he cannot live on land without water. In specializing his physical and mental functions through the centuries, *homo* (sometimes referred to by his critics as "sap," although we think this is a little too much familiarity)—well, anyway, *homo* has wisely preserved just enough vestigial functions for himself so that he can swim for short distances, can in some cases refrain from seasickness long enough to be propelled in ships to and fro between the continents and can even accustom himself in extremely rare cases and only when forced to do so, to the drinking of water as a beverage.

To compensate for the latter condition, man attempts to find as many other uses as possible for water. He puts it under bridges for the benefit of artists and suicides, he dissolves many of his manufactured products in it or uses it as a carrier for them, he washes himself and his goods in it, he flavors it in all sorts of ways so that he can delude himself into believing he is not drinking it and, probably most important, he uses it as an energy carrier in the form of steam.

What more important to man than his domestic water supply? Here's an article on the great Springwells Pumping Station in Detroit, showing how power is used to supply 500,000,000 gal. a day from this plant alone.

What if a boiler has ash conveyor breath or B. O. (boiler odor) or holeitosis of the drums? Even if its best friends won't say a word, still much can be done. Possibly it is not using the right brand of coffee or yeast. Possibly the water is not right, concentration may be too high, sulphate-carbonate ratio not correct and so on. Mr. Larson tells in this issue how to apply the proper engineering equivalent of Blisterine to correct the holeitosis or whatever it may be, while Mr. Sager presents a chart to help in interpreting the results of tests and to simplify boiler routine.

Almost every time you have to handle water, you will pump it somewhere along the line. Well, sometimes things go wrong even in the best of pumps and you have to do something about them. You can't just sit and look at them. Of course you have many ideas of your own about what to do and you will want to see what Mr. Emerson says about pumps in this issue.

The Monkey Gland Surgeons Are at It Again

As Mr. Sutherland explained in the Dec. 15, 1931 issue of Power Plant Engineering, the monkey gland surgeons have been most helpful to electrical engineers by rejuvenating existing equipment to make it do more and better things, thus getting more kilowatts out of the same old dollars. Now these monkey-gland surgeons have turned their attention to mechanical equipment. Among other things they have produced an all-purpose crane that can dig, scoop, lift, drag and push. Foundations, trenches, coal or ash piles, drag lines, car moving, placing of heavy pieces of equipment are its meat, with odd jobs of plant maintenance as a dessert course. Mr. Kohl tells some of their adaptabilities on page 338.

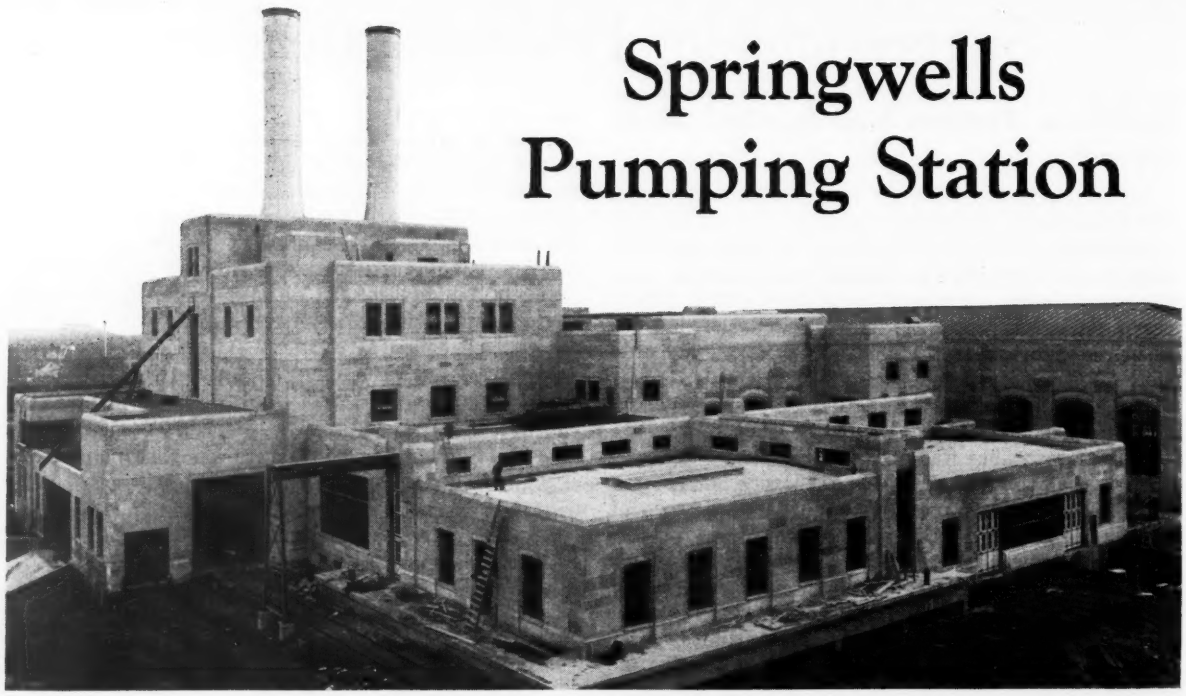
For Lifting Purposes, You Can't Beat a Good Pair of Bootstraps

Now don't tell us it can't be done, but just listen. At the DuPont synthetic ammonia plant at Belle, W. Va., water at about 300 lb. pressure is used for scrubbing gas. In the new installation, described on page 348, a spray tower was installed on top of a mountain and the pressure in the scrubbers forces the water up to the tower. Here it is deaerated and cooled, then flows down to the scrubbers again, the static head from the tower down to the pumps giving practically the entire pressure recovery, the pumps adding only the extra pressure to overcome pipe friction. Now tell us you can't do some pretty heavy lifting with bootstraps—if you know how!

Grinding a carload of coal in an hour is some job for a pulverizing mill. But they do it in the 50-t. mills at Kips Bay Station in New York as described on page 328. One of the pulverizers has been equipped with a third inner row of grinding balls. You will be interested to read about the results of tests on these mills with different coals of varying grindability. They are interesting as an indication of the general trend toward increased capacity of units to keep down fixed charges in large plants.

POWER PLANT ENGINEERING April 15 1932

Springwells Pumping Station



Low lift and high lift pumps, initial installation for 500,000,000 gal. a day, and 20,000 kw. steam turbine generating plant to drive them, are principal features of the new pumping station for the City of Detroit, Mich.

NEW DETROIT WATER WORKS on West Warren Avenue at Detroit Terminal Railroad, now being constructed for the Detroit Department of Water Supply and known as Springwells Station, is nearing completion. It consists of raw and filtered water pumps, motor-driven centrifugal type, all in one building; a switch house, turbine house and boiler house; and a filter plant and reservoirs.

Water from the Detroit River will be delivered to the low-lift plant through a 12-ft. diameter tunnel, Fig. 1. The plant is located about 11 mi. from the intake in the Detroit River. Low-lift pumps will lift the water to the coagulation basins of the filtration plant. After the water is filtered, part of it will flow to the high-lift plant through two tunnels and part will be delivered to the filtered water reservoirs.

The pumping plant, about 390 ft. long by 100 ft. wide by 50 ft. high above grade, houses both the low-lift pumps and the high-lift pumps. The low-lift plant is on the east end of this structure; the high-lift plant occupies the balance of the structure. The power plant consists of switch house, turbine house and boiler house. The switch house is 200 ft. long by 40 ft. wide by 50 ft. high with three stories and basement. The turbine room, 185 ft. long, 110 ft. wide and 60 ft. high, includes an auxiliary bay between boiler house and turbine house. The boiler house is a structure 90 ft. long by 130 ft. wide by 80 ft. high. In the rear of the boiler plant open coal storage space having capacity of 18,000 t. is provided.

A booster station has been built at Springwells and has been in operation since June, 1930, supplying water to the section of the water supply system that will eventually be served by the new station. In this booster station, three 17-m.g.d. motor-driven centrifugal pumps work against 180-ft. head and one pump rated at 17 m.g.d. against 130-ft. head. After the new pumping station is completed, it is planned to move these booster pumps into it.

Low-Lift Plant

The low-lift plant has circular substructure and rectangular superstructure. The substructure of this

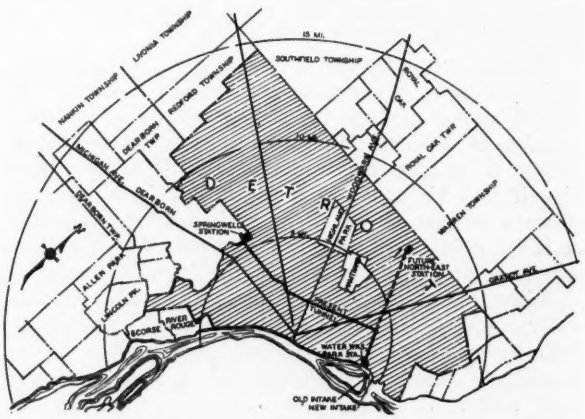


FIG. 1. MAP SHOWING NEW TUNNEL AND LOCATION OF SPRINGWELLS PUMPING STATION

plant, Fig. 4, was constructed as an open caisson 90 ft. in diameter and about 94 ft. below grade, 65 ft. of which was sunk as a caisson. The walls of the caisson are 8 ft. thick. This structure was sunk in soft blue clay and through 14 ft. of hard pan. Inside of this open caisson was constructed an inner wall, inside of which are placed the vertical-shaft, centrifugal motor-driven pumps. There will be ten of these pumps; the largest will have a capacity of 60,000,000 gal. per day against heads of 50 and 60 ft. Total rated capacity of all these pumps is 435,000,000 gal. per day. The design of this plant is such that the pumps could be operated submerged in case of flooding of the pump pit. Motors driving the pumps are located above high water in the river so that they will not become submerged in case of broken pump casing or pipe line. The two smallest pumps are arranged with suction piping connections so that they can be used to pump out the pit in case it becomes flooded. In the design of this plant, intensive studies were made of water surges from the tunnel due to sudden loss of motive power and operating conditions.

High-Lift Plant

Filtered water pumps in the high-lift plant, Fig. 3, will consist ultimately of sixteen units. The ultimate capacity of the sixteen units will be 680,000,000 gal. per day. Gross capacity of the twelve pumps for the initial installation will be 500,000,000 gal. per day.

The pump sizes are 30, 40 and 50 m.g.d. and they are divided into two different groups. One set of pumps will deliver water into the distribution system leading to the southeast and southwest districts of the city. The second group will deliver water to the northwest district of the city. Head for the pumps in the first group is 150 ft., for the second group 200 ft.

These pumps will be of the horizontal shaft centrifugal type driven by synchronous and slip-ring, variable-speed, remote control type motors. Since filtered water is pumped to the direct pressure system, it is necessary for the pumps to follow the load. It was decided to use about 80 per cent pump capacity in constant-speed synchronous-motor-driven units and the balance in the slip-ring induction, variable-speed, motor-driven units. This combination will give a wide range of capacity and result in most economical operation. Power for operation of the pumps will be supplied from the power plant, described below. These pumps, arranged in pairs, are set in individual pits about 19 ft. below grade inside the building, Fig. 3.

Discharge piping for these pumps is connected to two 72-in. steel pipe headers with two groups of headers, one group on each side of the building. This system with necessary valves is placed in a pipe-vault that forms part of the building. To the four groups of 72-in. pipe headers are connected six 72-in. force mains leading to the distribution system in the street. In each of these mains a Venturi meter tube measures the water delivered to the mains.

Superstructure to house both the low-lift and high-lift plant sections, is of steel, stone, terra cotta and brick construction with copper roof, as shown in the headpiece.

Power Plant

The power plant is a separate building from the pumping plant but connected to it. In the switch house building two switchboard rooms are located, one for the pumping plant and one for the power plant, as shown in Fig. 5. All pumps will be controlled from one point by a single operator. One operator will control the

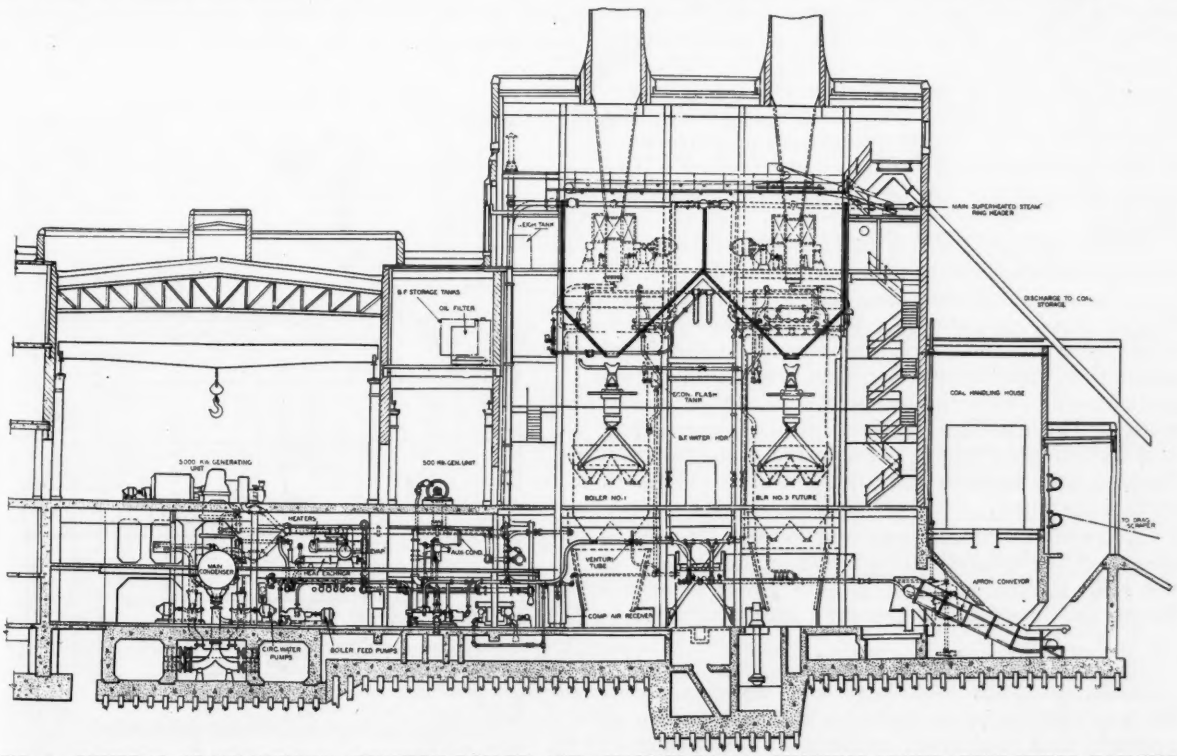


FIG. 2. GENERAL CROSS-SECTION THROUGH BOILER AND TURBINE ROOMS, SHOWING GENERATING UNITS, BOILERS AND COAL HANDLING EQUIPMENT

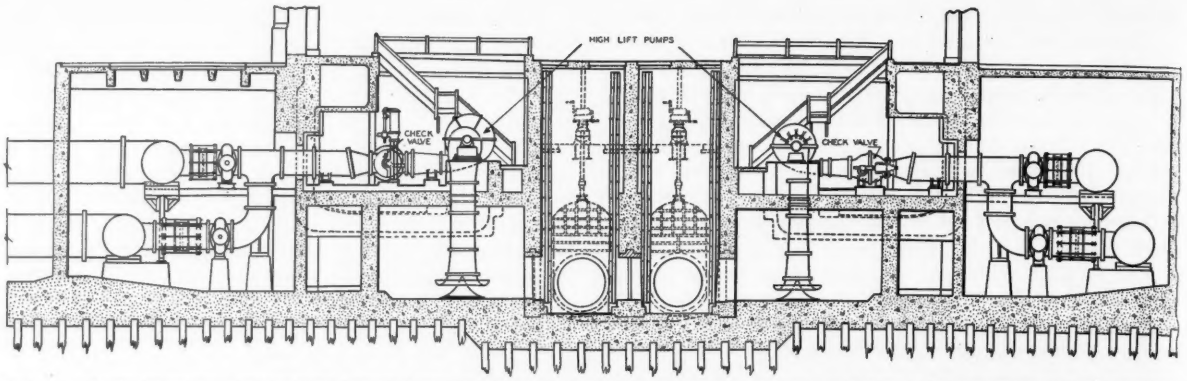


FIG. 3. CROSS-SECTION THROUGH HIGH-LIFT PUMPING PLANT SHOWING PIPING, VALVES AND HORIZONTAL MOTOR-DRIVEN CENTRIFUGAL PUMPS

prime movers and auxiliaries from the power plant switchboard room.

On the top floor of this building are placed the fans for ventilation of the pumping plant, consisting of forced draft fans blowing fresh air into the motor pits and a group of exhaust fans to draw air from the top of the building and from the bottom of the low-lift plant. On the second floor of this building are oil circuit breakers and switchboard; on the first floor reactors, resistors, rheostats and similar equipment. Switch gear of the metal-clad enclosed type has been used, with the object of eliminating open type disconnecting switches, concrete cell structure and the like.

Turbine house will contain ultimately four 5000-kw. 4600-v. 3-phase, 60 cycle, steam turbine generators; two of these units are installed for the initial installation, Fig. 2. These machines will operate condensing, with two extraction nozzles provided for heating feedwater in closed feedwater heaters. Condenser for each turbine will be 10,000 sq. ft. surface, 2-pass, power-plant type. Condensate is handled by two groups of pumps. The hotwell pumps force condensate through the heaters to the suction of the boiler feed pumps. The boiler feed pumps deliver water to the economizers at temperature of about 270 deg. and from these the feedwater will be delivered to the boilers at temperature of approximately 370 deg.

In the auxiliary bay, Fig. 2, four 500-kw. steam turbine generators generate power at 460-v., 3-phase, 60-cycle for the auxiliaries. This power will be used for driving motor-generator sets that will produce 240-v. direct current power for operation of power plant auxiliaries. Auxiliaries other than essential machines in the power plant will be operated by 440-v. 3-phase motors. The auxiliary turbines, of the bleeder type, will furnish low-pressure steam to the heating system. Each of these turbines is equipped with an 800-sq. ft. surface condenser.

A transformer bank equivalent to 5000 kw. will be connected to a central station feeder or the capacity of one main turbine generator and the power plant will be operated in parallel with central station supply.

Boiler Plant

Boiler plant has been designed, as shown in Fig. 2, for four 1000-hp. boilers operating at 360 lb. per sq. in. pressure, with total steam temperature of 715 deg. F. Initial installation will consist of two boilers of the 4-drum bent-tube type; furnaces are equipped with water-cooled side walls.

The furnaces are fired by motor-driven underfeed stokers and will be equipped with economizers and air preheaters. Air for combustion will be delivered to stokers at about 260 deg. F. Forced and induced fans will have capacity of 45,000 and 75,000 c.f.m. respectively.

All power plant auxiliaries will be motor-driven, operated by 230-v. direct current. Ring bars will be provided throughout the power plant. Power will be supplied by two 400-kw. motor generator sets, operating 460-v., 3-ph., 60-cycle auxiliary power system.

Coal received by railroad is unloaded into a hopper on the north end of the boiler house. From this hopper, the coal will be fed through a crusher, then into a bucket elevator and thence to a belt conveyor, which will distribute it into a 600-t. concrete coal bunker. The ash handling system will be of the hydraulic sluicing type. Ash discharges from the stokers into a hopper, whence

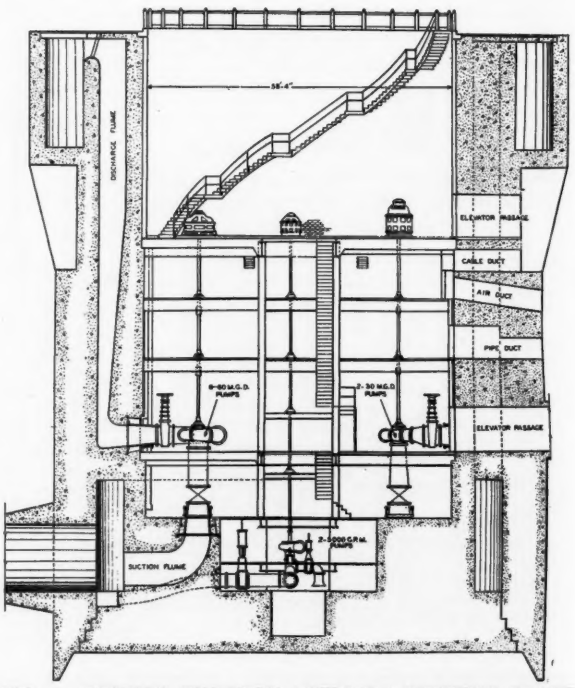


FIG. 4. SECTION THROUGH LOW-LIFT PUMPING PLANT

it is removed by sluice to a pit and pumped from this pit to an overhead tank. From this tank, the ash may be loaded into trucks or railroad cars.

One of the unusual features of the power plant will be its ability to start large pump motors, since the power plant is small as compared with the pump motors. The other main feature is the immense heating load that needs be carried in the winter time. The calculated maximum heating load is 30,000 lb. per hr. of steam, based on steam at 5 lb. gage pressure.

It is expected that the heat balance for this plant will show economy of about 19,000 B.t.u. per net kilowatt-hour. Coal consumption for the plant for estimated conditions in 1932 is expected to be about 75 t. daily. The ultimate coal consumption will be approximately 140 t. daily.

These plants are being designed and constructed by the Board of Water Commissioners, Alex Dow, engineer member, of the City of Detroit, under the general direction of George H. Fenkell, general manager and chief engineer, who is assisted by Frank H. Stephenson, engineer of water system and assistant chief engineer. The Bureau of Power of the Department of Water Supply is responsible for the design of the pumping and power plants, under the direction of William C. Rudd, assistant engineer power. The structural design is under the supervision of Frank E. Simpson, associate structural engineer. Bernard J. Mullen, assistant mechanical

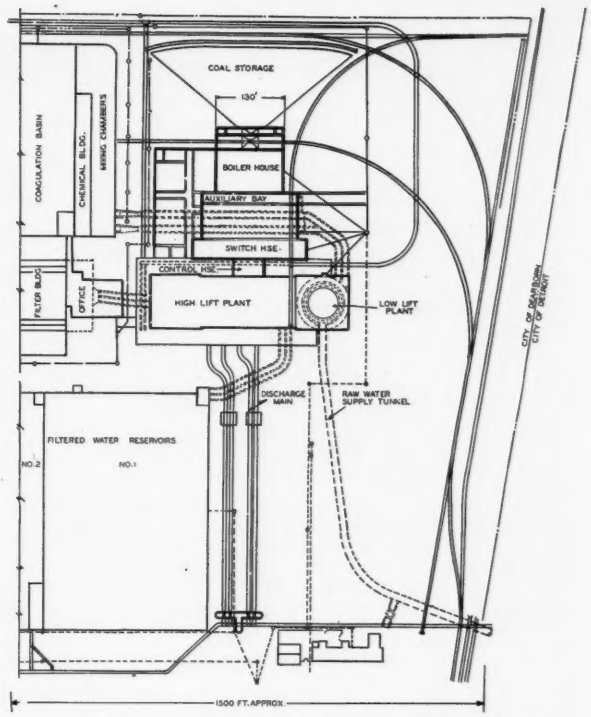


FIG. 5. GENERAL ARRANGEMENT OF SPRINGWELLS PUMPING STATION

Principal Power Plant and Pumping Equipment at Springwells Pumping Station—Detroit, Michigan

Contractors for foundation and low lift plant substructure—E. H. Latham Co.

Power plant substructures — W. E. Wood Co.

Pumping plant structure—Bryant & Detwiler Co.

PUMPING EQUIPMENT

Low lift vertical centrifugal pumps—8 Worthington Pump & Machinery Corp.; two 30-m.g.d. units driven by General Electric variable-speed slip-ring motors. Six 60-m.g.d. units driven by General Electric synchronous motors. Part of pumps for 50-ft. head and others for 60-ft. head.

Dewatering and sump pumps—4, American Wells Works, driven by G. E. squirrel-cage motors.

High lift pumps—12, Worthington Pump & Machinery Corp. horizontal centrifugal. Two 30-m.g.d. units 200-ft. head, driven by variable-speed G. E. slip-ring motors. Two 40-m.g.d. 130-ft. head units, var. sp., G. E. slip-ring motors. Four 40-m.g.d. 200-ft. head; two 50-m.g.d. 150-ft. head, two 50-m.g.d. 130-ft. head units all driven by G. E. synchronous motors.

Booster Pumps—3, Byron-Jackson Co., 17-m.g.d. 180-ft. head, motor-driven centrifugal.

TURBINE-GENERATORS AND AUXILIARIES

Turbine-Generator Sets—2, General Electric Co., 5000 kw. each, extraction type; steam pressure, 350 lb., 700 deg. total temp. Generators 6250 kv-a., 4600 v., 3 phase, 60 cycles.

Condensers—2 C. H. Wheeler Mfg. Co. 2-pass, each to condense 60,000 lb. an hr., with four 4025-g.p.m. circulating water pumps and two-stage steam jet air ejectors.

Hotwell Pumps—4 Worthington Pump & Machinery Corp. 250 g.p.m. each.

Turbine Generator Sets—3 General Electric Co. 500 kw. each, extraction type, 350-lb. pressure, 700-deg.; generators, 625 kv-a. 460-v.

Condensers for above—3 Worthington Pump & Machinery Corp. 2-pass, 800-sq. ft. units with condensate pumps, circulating pumps and air ejectors.

Extraction Heaters — 4 Griscom-Russell Co., low pressure, 60,000 lb. an hr. capacity each.

Evaporators—2 Griscom-Russell Co., 2000 lb. an hr. each, single-effect.

Heat Exchangers—2 Griscom-Russell Co.

Boiler Feed Pumps — 3 Pennsylvania Pump & Compressor Co., 6-stage, 300-g.p.m., 1050-ft. head.

BOILERS AND AUXILIARIES

Boilers—2 Combustion Engineering Corp. 4-drum water tube, 10,388 sq. ft. each, 70,000 lb. steam an hr. each, 375 lb. pressure. Furnace walls, plain-tube water cooled.

Superheaters—2 Superheater Co., convection type, to give 715 deg. total steam temperature.

Economizers—2 Babcock & Wilcox Co., 2430 sq. ft. each, return-bend loop type.

Air Preheaters—2 Air Preheater Corp. Ljungstrom, 9980 sq. ft. each.

Stokers—2 Westinghouse Electric & Mfg. Co. underfeed, each 8-retort, 27-tuyere, designed to burn coal at maximum rating 10,000 lb. per hr.

Forced Draft Fans—2 Green Fuel Economizer Co. each 45,000 c.f.m., 13.5 in H_2O.

Induced Draft Fans—2 Green Fuel Economizer Co., each 75,000 c.f.m., 11 in. H_2O.

Coal Handling Equipment—Link-Belt Co., including drag scraper, apron feeder, crusher, bucket elevator, belt conveyor and tripper, 100 t. an hr. capacity.

Ash Sluicing System — Allen-Sherman-Hoff Co., Hydrojet, including hoppers, ash pumps, clinker grinder, ash storage bin.

OTHER ELECTRICAL AND MECHANICAL EQUIPMENT

Switching Equipment, switchboards and motor-generator sets—Westinghouse Elec. & Mfg. Co.

Passenger Elevator—1, for low lift plant—Otis Elevator Co.

Elevators for power plant—3—Warner Elevator Mfg. Co.

Water Check Valves for pumps, 8—Automatic Cone Valve Co.

Water Check Valves for pumps, 8—I. P. Morris & DeLaVergne, Inc.

Cranes, two 40-t., one 10-t., one 5-t.—Northern Engineering Works.

Automatic Telephone System—Automatic Electric, Inc.

Clocks—International Time Recording Co.

Soot Blowers—Diamond Power Specialty Corp.

Blowoff Valves—Eckenroth Valve & Mfg. Co.

Safety Valves—Crosby Steam Gage & Valve Co.

Electric Motors—
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Crocker-Wheeler Electric Mfg. Co.
Reliance Elec. & Eng. Co.

Motor-Generator Sets — Westinghouse Elec. & Mfg. Co.

Venturi Meters—Power Plant Supply Co.

Flow Meters—Dalley & DuBois, Inc.

Air Filters—American Air Filter Co.

Ventilating Fans—Clarage Fan Co.

Boiler Settings—Lyons & Long Co.

Water Level Gages—Bailey Meter Co.

Power Plant Piping—Freyn Bros.

Auxiliary Piping—Lorne Plumbing & Heating Co.

Power Transformers — Westinghouse-Kuhlman Electric Co. and Allis-Chamlers Mfg. Co.

Storage Batteries—Electric Storage Battery Co.

engineer, supervises the mechanical and hydraulic designs and Carl J. Schoeninger, chief electrical inspector, is in charge of electric power, lighting and electric equipment design. L. G. Lenhardt, assistant engineer, is in charge of field supervision for structural work on the pumping and power plants.

Ayres, Lewis, Norris and May, consulting engineers of Ann Arbor, were consultants on this work on certain features of hydraulic design, electric motors and electric switching equipment. E. R. Little Co., consulting engineers of Detroit, supervised the heating, ventilating and plumbing systems. The architect is John C. Thornton of Detroit.

Kips Bay High Capacity Coal Pulverizers

TESTS ON MILL THAT WILL PULVERIZE A CARLOAD AN HOUR, FOR VARIOUS COALS. BY PERCY CASSIDY*

KIPS BAY STATION of the New York Steam Corp. located at the foot of 35th St. and East River, New York City, was completed and placed in service in December, 1926, with a total capacity of 975,000 lb. per hr. of steam pressure of 300 lb. A fourth unit was added in 1927, bringing the total capacity of the station up to 1,300,000 lb. of steam per hour. The rapid increase in the demand for central station steam in 1928 and 1929 made it necessary, in 1930, to begin the installation of another steam-generating unit and additional pulverizing equipment.

New pulverizers, Units 6 and 7, consist of two Fuller Lehigh type B mills with auxiliary equipment, now rated at 51 and 30 t. per hr. respectively for coal of 80 grindability or better.

POWER CONSUMPTION 14.7 KW.-HR. PER T.

Unit 6, the 51-t. mill, designated as a No. 82-60 type B. mill, is the first type B mill to be supplied with a third inner row of grinding balls. This row of balls has an independent upper grinding ring, spider and spring system. Unit 7, the 30-t. mill, is designated as a No. 60 type B mill. The expected performance for units 6 and 7 were based upon pulverizing Pittsburgh coal, crushed to pass through a ¾-in. ring, moisture to

DATA FOR TWO TESTS ON EACH MILL

	Unit 6. 51-ton Mill			Unit 7. 30-ton Mill		
	Expected Performance*	Test Results		Expected Performance	Test Results	
Grindability of coal	65	62	76	65	63	76
Mill capacity, tons per hr.	40	44	54	25	28.8	30.6
Mill kw-hr. per ton	9.5	10.3	9.5	10.0	7.8	7.35
Exhauster kw-hr. per ton	5.0	3.6	2.9	4.5	3.0	2.7
Feeder kw-hr. per ton	0.2	0.08	0.08	0.2	0.09	0.08
Total kw-hr. per ton	14.7	13.98	12.48	14.7	10.89	10.13
Total air from mill cu. ft. per min.		22,000	22,500		16,900	15,820
Total air from mill cu. ft. per lb. coal		15.0	12.5		17.5	15.5

be not over 6 per cent with coal having a grindability of 65 or better provided that preheated air at 400 deg. F. is available for use in the mill.

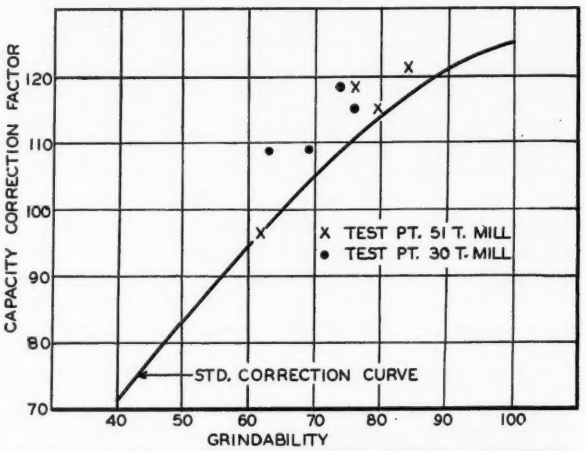
Expected performance of mill No. 6 was 40 t. per hr. with a fineness of 70 per cent through 200 mesh and 98 per cent through 40 mesh. Expected power consumption was 9.5 kw-hr. per t. for the mill, 5.0 for the exhauster and 0.2 for the feeders, a total of 14.7 kw-hr. per t.

*Babcock & Wilcox Co. From a paper presented before the Metropolitan Section of the A.S.M.E.

Under the same conditions, the expected performance for mill No. 7 was 25 t. per hr. with a power consumption of 10.0 kw.hr. per ton for the mill, 4.5 for the exhauster and 0.2 for the feeders, a total of 14.7 kw-hr. per ton. Expected maintenance material cost of both mills is not over 2 cents per ton.

A large number of tests were run on both mills for experimental data prior to the acceptance tests. Results of two of the tests on each mill are given in the table for low and high grindability coal. In all of these tests the fineness of the pulverized coal complied with the specification of 70 per cent through the 200 mesh and 98 per cent through the 40 mesh.

A standard capacity correction curve for various grindabilities suitable for type B and type C mills is given by the curve. The capacity of 65 grindability, which is the basis of the guarantees in units 6 and 7



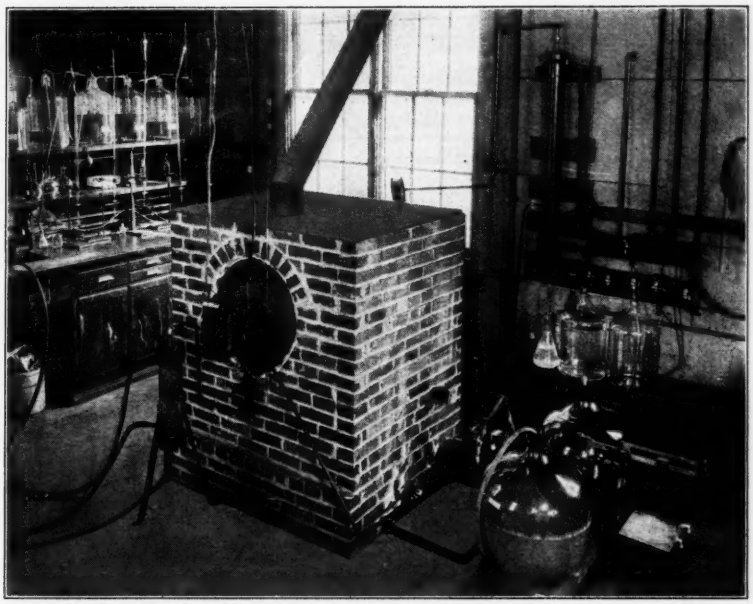
STANDARD CAPACITY CORRECTION CURVE AND EIGHT TEST POINTS OF ACTUAL CAPACITY

of Kips Bay Station, is rated at 100 per cent capacity on the correction curve. For any other grindability of coal the capacity of either mill may be determined. The four test points plotted for each mill show that the capacity curves within the limits of grindability experienced at this plant are conservative.

NINE HUNDRED THOUSAND pounds of steam a day at average rate of 65,000 lb. an hour or more is to be supplied at 175 lb. and 100 deg. or more superheat to Eli Lilly Co. by the Indianapolis Light and Power Co. Boiler pressure will be 250 lb. and superheat 200 deg. For the first 2600 ft., 16-in. pipe will be used and 10-in. for the last 2600 ft. Velocity is to be 4600 ft. per min. in the smaller pipe, and only 2100 ft. per min. in the larger section until other supply is connected. The pipe line is carried on rollers, covered with 3½-in. insulation and enclosed in a conduit having reinforced concrete base and cover and tile sides. Every 300 ft. is a manhole carrying two packed sleeve-expansion joints, anchors of concrete and I beams being installed between these joints in the manholes, also at points midway between manholes. Each joint is to care for 8 in. expansion of 150 ft. of pipe line. Conduit and manholes are set on gravel with 4-in. drain tile below and to each side of the run. Traps are installed in separate manholes at low points, their condensate discharge being wasted to the sewer. Data are given by Robt. L. Fitzgerald in Heating, Piping and Air Conditioning.

Caustic Alkalinity In Boiler Waters[1]

By
Reinhold F. Larson[2]



HIGH-PRESSURE EXPERIMENTAL BOILER

FEW NATURAL waters, and some treated waters, are caustic when they enter the operating boiler. Most of them become somewhat caustic under the action of boiling at high temperatures. This phenomenon was noticed as early as 1891,[3] and a few years later was brought to a focus as being the possible cause for a series of boiler failures from what later came to be recognized as caustic embrittlement.

This development of a caustic soda content in the boiler is due primarily to the chemical breakdown of the carbonates and bicarbonates in solution. The first step in the process is what the chemist calls hydrolysis. Because the carbonates are salts of a weak acid, and of a strong alkali, they cause water to have an alkaline reaction when they go into solution. Thus:

$Na_2CO_3 + 2H_2O = 2NaOH + H_2CO_3$ or,

sodium carbonate (soda ash) + water = sodium hydroxide (caustic soda) + carbonic acid.

This occurs at any temperature. On raising the temperature the carbonic acid becomes unstable and gives off carbon dioxide as a gas. Thus:

$$H_2CO_3 = H_2O + CO_2$$

This gas becomes entrapped in the steam bubbles as they form, is carried into the steam space above the water and, finally, out of the boiler along with the steam. Combining the two equations and considering only the final products, we can express the reaction as:

$$Na_2CO_3 + H_2O = 2NaOH + CO_2$$

It is probable that there are some intermediate steps, and some interaction between the intermediate products, but for this purpose, only the final products need be considered.

The caustic soda formed is very soluble and can leave the boiler only in the small amount of water carried over with the steam, or in the process of blowing down. It therefore accumulates and concentrates in the boiler water under all ordinary conditions of operation and makes the boiler water extremely caustic in a short time. The carbon dioxide cannot accumulate in the boiler, hence a static chemical equilibrium cannot be established and the reaction proceeds continuously to increase caustic soda. A supply of carbonate is constantly being brought into the boiler with the feedwater so that there is always some present undecomposed.

This process of decomposition is common to all carbonates contained in a feedwater. Many of these, however, such as calcium carbonate are only slightly soluble and their contribution to the causticity in the boiler water is very small. The presence of magnesium chloride is known to accelerate the decomposition of calcium carbonate somewhat. The use of sodium phosphates as a secondary treatment of a boiler water converts some of these slightly soluble carbonates into soluble sodium carbonate and precipitates out insoluble phosphate. The sodium carbonate thus formed, breaks down and increases the causticity.

Extent of Decomposition Reaction

Many attempts to determine the extent of this reaction have been made, some on small experimental boilers that did not duplicate actual boiler operation,[4] and others on actual plant boilers.[5] Little information was gained as to the factors controlling the reaction. The author in attempting to study this problem built a miniature high pressure boiler, and operated this boiler in a way comparable with actual boiler operation, and was able to isolate and control the various factors. The effect of each factor could then be observed. The boiler is shown in the headpiece.

Convenient designation of the extent of this reaction is to express the carbonate and the hydroxide in terms

[1]Part of research suggested by F. G. Straub, Special Research Assistant Professor of Chemical Engineering in the Engineering Experiment Station, and conducted in the Graduate School of the University of Illinois under the general supervision of D. B. Keyes, Professor of Industrial Chemistry.

[2]Instructor, Department of Mechanical Engineering, University of Illinois.

[3]Paul, J. H., Trans. Soc. Engrs. (1891) pp. 147-186.

[4]Hall and others, Bulletin 24, Mining and Metallurgical Investigations. Carnegie Institute of Technology.

[5]Joos, C. E., Power, Nov. 12, 1929, pp. 762-764.

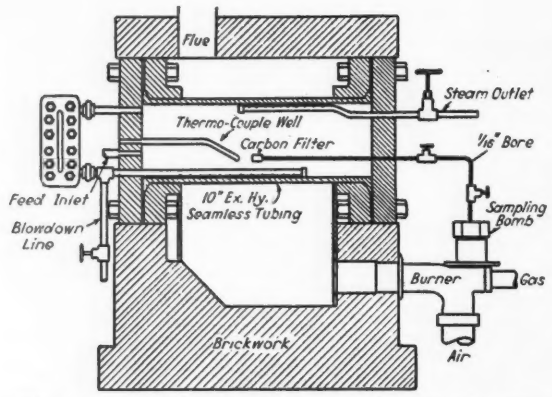


FIG. 2. CONSTRUCTION AND CONNECTIONS OF TEST BOILER

of the former and arrange them in the form:

$$\frac{(NaOH)\text{ expressed as }Na_2CO_3 \times 100}{(NaOH + Na_2CO_3)\text{ expressed as }Na_2CO_3} = \text{Per cent Decomposition.}$$

This value has been observed to vary from as low a value as 20 per cent in some boilers, to as high a value as 90 per cent in others.[5] The amount of carbonate that can exist in an operating boiler is of importance in determining the treatment necessary to inhibit embrittlement, and possibly to prevent scale formation.[6]

A section of the boiler used by the author in these tests, is shown in Fig. 2. Gas was used as a fuel, and distilled water, free of CO_2, treated to various concentrations of sodium carbonate, was continuously fed to the boiler by means of a small high-pressure displacement pump. A constant water level was maintained, and samples of boiler water were withdrawn under pressure into a small steel bomb and preserved for analysis. The steaming rate was about 90 lb. an hour, approximately two concentrations occurring per hour. This rate of steaming is less than that of the modern boiler but the steam was condensed and wasted in this case and the make-up was 100 per cent, so that the rate of building up concentration is comparable with the large plant boiler.

Samples of water withdrawn were carefully analyzed for Na_2CO_3 and NaOH and the per cent decomposition calculated. Various boiler pressures were tried, from 150 to 1500 lb. per sq. in. gage. The results have been plotted in various ways. Figures 3, 4, and 5, show the results obtained for various pressures and composition of feedwater. It is evident that a maximum decomposition is reached in each case, dependent upon pressure and feedwater concentration and, to some extent, upon total alkalinity of the boiler water. Apparently a dynamic or operating equilibrium is reached.

To check the total alkalinity factor a blow-down system was installed and operated to keep the boiler concentration (in this case alkalinity) constant. This resulted in maintaining a constant value of decomposition for each set of conditions. A test was run with sodium bicarbonate, $NaHCO_3$, in the feed in amount sufficient to give the same sodium concentration but twice the amount of available carbon dioxide. This reduced the decomposition as seen in Fig. 6, showing that an important factor in controlling the extent of decomposition is the amount of available carbon dioxide in the feedwater. The higher pressure of CO_2, due to the greater amount, in the steam space causes apparently a greater reconversion of NaOH back to Na_2CO_3. The reaction can apparently be reversed by building up the carbon dioxide in the steam space and the concentration of the sodium hydroxide in the boiler water.

Several tests at higher and lower steaming rates were run. The results are shown in Fig. 7, and indicate that the equilibrium set up is practically independent of the steaming rate. Figure 8 shows that the presence of large amounts of a neutral salt such as sodium sulphate has practically no effect upon the decomposition. Sodium sulphate is present to some extent in most boiler waters and is often added in definite amounts to prevent embrittlement.

Figure 9 is drawn from a collection of data at a total alkalinity of 2400 parts per million, and represents the maximum decomposition possible with various feedwaters containing sodium carbonate alone as the substance decomposed. In Fig. 11 these data have been replotted in the form of the ration of Na_2CO_3 to NaOH, to make it directly applicable in connection with the use of Fig. 13. Two similar sets of curves representing the ratios that can exist at alkalinities of 1200 and 7200 parts per million as Na_2CO_3, are given in Figures 10, and 12. These curves can be used in checking analyses of boiler waters where the conditions of feed are known. They are based on attaining the dynamic equilibrium previously referred to, the total alkalinity being held

[6]Partridge, Schroeder, and Adams. Preprint. "The SO_4-CO_3 Ratio for the Prevention of Sulphate Boiler Scale." Annual Meeting, New York. American Society of Mechanical Engineers. Nov. 30—Dec. 4, 1931.

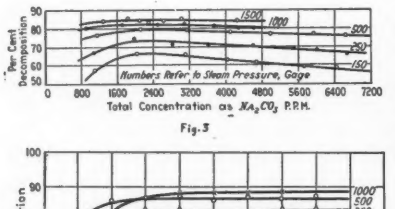


Fig. 3

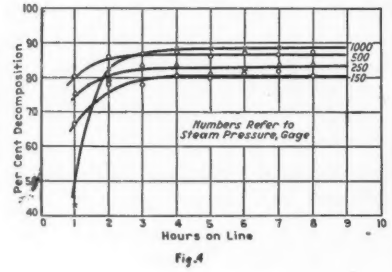


Fig. 4

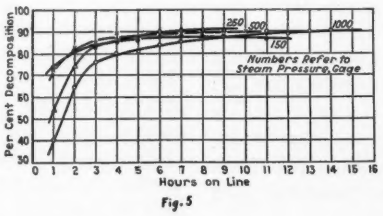


Fig. 5

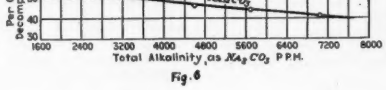


Fig. 6

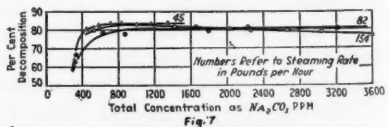


Fig. 7

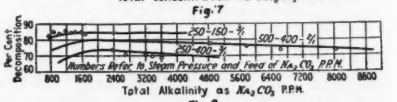


Fig. 8

DECOMPOSITION VARIATION. SODA ASH IN FEED, P.P.M.; FIG. 3, 400; FIG. 4, 150; FIG. 5, 50; FIG. 6, 400, AT 150 LB. PRESS., EFFECT OF PARTIAL PRESSURE OF CO_2; FIG. 7, 150, AT 150 LB. PRESS., VARIOUS STEAMING RATES; FIG. 8, EFFECT OF SODIUM SULPHATE PRESENT IN RATIOS AS SHOWN BY FRACTIONS; CURVES FOR NO Na_2SO_4; CIRCLES WITH Na_2SO_4

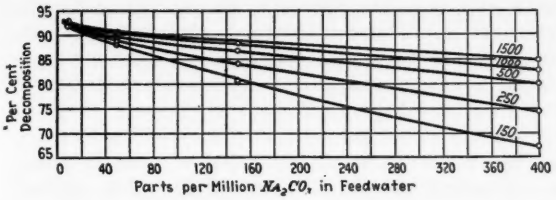
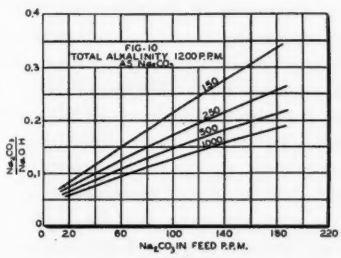
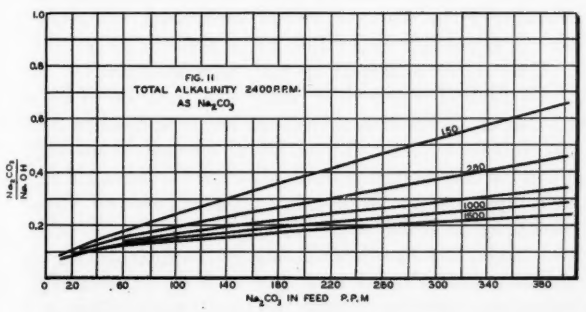


FIG. 9. MAXIMUM DECOMPOSITION FOR TOTAL BOILER WATER ALKALINITY 2400 P.P.M. AS Na_2CO_3

constant by means of blowdown. Ratios for various alkalinities and pressures may be read directly or by interpolation. In the case of a condensing plant, the feedwater analysis would be that of the combined condensate and make-up as it enters the boiler.

Some factors that will affect the decomposition rate in the actual boiler and cause the establishment of somewhat different ratios than these, are as follows: Feedwater may actually contain bicarbonates due to the presence of large amounts of carbon dioxide in solution in the condensate. In the case of a lime-soda softener, insufficient lime, in the case of an open heater insufficient temperature, or in the case of closed heaters insufficient deaeration may cause the feedwater to contain bicarbonates. In some cases, the feedwater is purposely made bicarbonate with flue gases to avoid deposits in heaters and economizers. These will favor the maintenance of a higher percentage of carbonate in the boiler. Over-treatment with lime may result in a lower percentage of carbonate. Improper sampling and exposure of the sample to the atmosphere, tend to increase the carbonate content at the expense of the hydroxide. Some methods of analysis tend to give too high a value for carbonates.





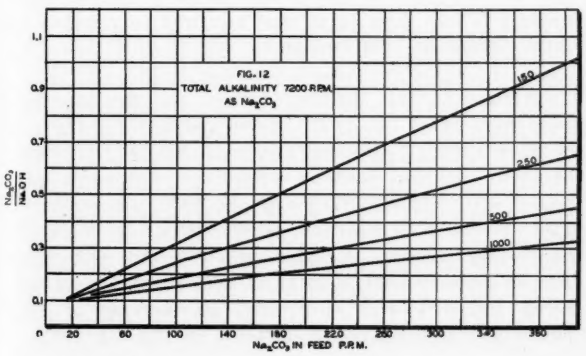


FIG. 10-12. RATIO SODA ASH TO CAUSTIC SODA FOR TOTAL BOILER WATER ALKALINITIES SHOWN AND MAXIMUM DECOMPOSITION WITH SODA ASH ONLY IN FEED WATER. NUMERALS ON LINES ARE GAGE PRESSURES

Boiler Water Analysis

In the above tests the samples of boiler water were cooled within the bomb, the air pressure released, the contents quickly poured into clean flasks and the flasks stoppered. Later they were analyzed by the A. P. H. A. method, using phenolphthalein and methyl orange as indicators, and checked by the Winkler method, using slightly alkaline barium chloride to precipitate out the carbonates, then titrating to the endpoint with phenolphthalein to determine the hydroxide. Checks for the two methods were good in all cases where no sodium sulphate was present.

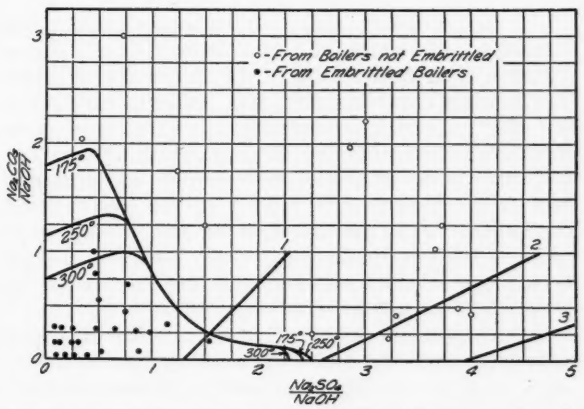


FIG. 13. RELATIVE RATIOS OF SODA ASH AND SODIUM SULPHATE TO CAUSTIC SODA TO PREVENT EMBRITTLEMENT

In the presence of appreciable amounts of sodium sulphate the Winkler method gives too low a value for hydroxide. The A. P. H. A. method is less affected and was used in the calculations. The methyl orange endpoint, however, becomes harder to determine.

Fiftieth normal acid was used for the lower concentrations and twentieth normal for the higher concentrations, enough of the sample being titrated each time to get a burette reading of at least twenty. This is important, inasmuch as it practically eliminates the use of a blank, simplifies the procedure and tends to greater accuracy. It is also important that the titrations be made quickly to avoid undue contact with air and breath. Standard pipettes are desirable for measuring and transferring the sample to be titrated. When dealing with hydroxide solutions the pipettes should be rinsed with the sample before the measurement is made.

For the best work, one should know approximately where the endpoints or color changes lie so as not to over-run. This calls for checks, the check carrying more weight than the first analysis.

Too much indicator is not desirable, particularly in the case of methyl orange where less gives a more distinct color change. The titration is best done in a small-mouthed Erlenmeyer flask whose capacity is not over

three times the amount of sample used. The sample must be agitated during titration so as to mix the acid well. These determinations are extremely difficult to make in light other than daylight.

It is felt that results in these tests are substantially correct. Methyl orange is a good indicator for total alkalinity, which in this case could be only the sum of the carbonate and hydroxide alkalinities. Prof. Straub has made a direct comparison of the various methods ordinarily used and reported on their reliability.[7] When the carbonate content is less than 100 parts per million and the hydroxide very high in comparison, it is extremely difficult to determine the carbonate content by any direct titration method. The only reliable method under these conditions is to break down the carbonates by making strongly acid, boiling and absorbing the CO_2 in askarite, or in standardized barium hydroxide. Schroeder and Fellows[8] have devised an apparatus suitable for this kind of determination and adaptable to the power plant laboratory.

Inhibition of Embrittlement

In an operating boiler, the carbonate content may be used as an inhibitor of caustic embrittlement. Figure 12 taken from Bulletin 216 of the University of Illinois Engineering Experiment Station, indicates the protecting effect of carbonate and sulphate when they appear together, as they often do. When the ratio of carbonate to hydroxide is not sufficient to prevent embrittlement, enough sulphate may be added to get into the safe region above and to the right of the curves, where embrittlement is unlikely to occur. To know the carbonate content is therefore important, as less of the other inhibitor will have to be added.

It is apparent that the industrial plant operating with large make-up and high boiler concentration can profit most, as the decomposition for these conditions is less, the carbonate-hydroxide ratio greater and less sulphate necessary. The central station with its evaporated make-up and relatively pure feedwater would find it very difficult to maintain much carbonate and would have to find safety in maintaining sufficient sulphate, or use some other inhibitor such as phosphate.

It is usually contended that high concentration of soluble salts in a boiler water is the principal cause for foaming and priming. Boilers are blown down for that reason. The development of the theory of film and foam formation and the later researches of C. W. Foulk indicate that, not the total amount, but the kinds of substances in solution and suspension in a boiler water, control its tendency to foam and prime. One substance may neutralize the foam-forming tendency of another. This seems to offer the possibility of operating at high concentrations which favor the maintenance of carbonate in the boiler. Some industrial plants operate successfully at high concentrations with the use of an efficient steam purifier to eliminate carry-over.

It appears that safety from embrittlement cannot be attained from the carbonate-hydroxide ratio alone, unless the feedwater is distinctly bicarbonate and the boiler water concentration very high. Cases have been encountered where plants have been operated for years with what might be classed as an embrittling feedwater, yet have apparently maintained sufficient carbonate in the boiler to prevent embrittlement. These are extreme cases, however, and unless operators are certain that their analytical determinations are correct, they would do well to investigate the sulphate-hydroxide ratio, or the A. S. M. E. sulphate-alkalinity ratio, in order to avoid embrittlement. Professor Straub has outlined a procedure that is very simple and complete, in the December 1, 1931 issue of Power Plant Engineering that need not be repeated here.

[7]Straub, F. G., Power Plant Engineering, Dec. 1, 1931, pp. 1136-1140.

[8]Schroeder and Fellows. Preprint. "The Determination of Carbonate, Hydroxide, and Phosphate in Boiler Waters." Annual Meeting, New York, Nov. 30—Dec. 4, 1931. American Society of Mechanical Engineers.

Prevention of Scale

Maintenance of a CO_3 to SO_4 ratio to prevent the deposition of a calcium sulphate scale was originated by R. E. Hall.[4] The value of this ratio was extremely high and it was doubtful whether this could be maintained due to the decomposition of the soda ash necessary. Recent investigation[6] has pointed out that this ratio should be an approximate minimum of 100 to 1, a ratio which should be easier to maintain. These decomposition data may be useful in conditioning various feedwaters to make them less likely to deposit a calcium sulphate scale in the boiler.

Gain by Compressed Air Reheating

Following calculation shows beneficial results theoretically obtainable by reheating compressed air:

Weight of 1 cu. ft. of steam at 75 lb. gage = 0.2089 lb. Total heat units in 1 lb. of steam at 75 lb., produced from water at 60 deg. F. = 1151. Total heat units in 1 cu. ft. of steam at 75 lb. = 1151 × 0.2089 = 240.44.

To produce 1 cu. ft. of compressed air at 75 lb. gage and 60 deg. F. in a steam-actuated air compressor, about 2 cu. ft. of steam at the same pressure are required, making the thermal cost of 1 cu. ft. of compressed air, at the above temperature and pressure, 240.44 × 2 = 480.88 heat units. The air here is supposed to have lost its heat of compression by being stored or transmitted to a distance, so that the 480.88 heat units represent its cost at the motor where it is to be used.

The result of reheating may now be stated:

Weight of 1 cu. ft. of compressed air at 75 lb. and 60 deg. F. = 0.456 lb. Units of heat required to double the volume of 1 lb. of free air at 60 deg. F. = 123.84. Units of heat required to double the volume of 1 cu. ft. of compressed air at the same temperature and pressure = 123.84 × 0.456 = 56.47.

Comparing the thermal cost of 1 cu. ft. of air compressed in a cylinder with that of 1 cu. ft. obtained by reheating: 480.88 ÷ 56.47 = 1 ÷ 0.1174. That is, the cost in heat units of the volume of air produced by reheating is less than ⅛ of that required to produce the same volume by compression.

Report of the Midland United Co. for the fiscal year ended Dec. 31, 1931, shows a deficit for the year of $1,008,107.74. During the year 901,745,609 kw-hr. of electricity was sold by subsidiary companies, compared with 919,613,197 kw-hr. in 1930, a decrease of 1.94 per cent. In addition, 76,897,922 kw-hr. were sold to electric railways operated by subsidiary companies. At the close of 1931, a total of 327,638 customers were being supplied with electricity, an increase of 19.63 per cent over the number supplied on Dec. 31, 1930.

Care and Operation of Evaporators

DETAILS OF OPERATION, SEAL CRACKING AND MAINTENANCE AS RECOMMENDED BY THE N. E. L. A.

EFFICIENT POWER PLANT operation demands that all auxiliaries be maintained in first class condition and that operators know how to operate them to best advantage under all load conditions. Evaporators are just beginning to take their place in industrial plants and for this reason the following detailed directions are of unusual interest.

PUTTING AN EVAPORATOR INTO SERVICE

1. See that the water supply lines and exhaust steam lines to the evaporator heater are in operating condition.
2. Start the evaporator feed pumps.
3. See that all blowdown valves are closed and the vent of each shell is open.
4. Fill each shell to the running water level, as indicated by the mark on the shell (....) in. above the center line of the manifold.
5. Open the vents on the traps on both high and low-pressure coils.
6. Open wide the vapor valve on the first effect.
7. Open the vapor valve on the second effect.
8. Open slowly the high-pressure steam valve to the first effect coils, noting that the reducing valve maintains (....) lb. gage pressure.
9. Maintain (....) steam temperature by adjusting the boiler feedwater supply to the desuperheater.
10. See that the trap is functioning on the steam separator.
11. Close the vents on the shells when the steam appears.
12. Slowly build up pressure in the shell of the first effect to (....) lb. by increasing the live steam to the coils of the first effect until (....) lb .at (....) deg. Fahr. is maintained at the entrance of the coils.

TAKING AN EVAPORATOR OUT OF SERVICE

1. Close the high-pressure steam valve to the first effect coils.
2. Close the water line to the desuperheater.
3. See that the float valves shut off the water after evaporation stops.
4. Close the vapor valve on the second effect shell.
5. Shut down the evaporator feed pump.
6. Divert any traps or drains entering the shell to another heater or to free blow.

CRACKING DOWN EVAPORATORS—FIRST EFFECT

1. Close the hand valve on the automatic feedwater valve control.
2. Close the steam valve to the coils and blow down the first effect evaporator shell completely through the blow-down line.
3. Close the blowdown valve.
4. Open the vent valve.
5. Fill the first effect evaporator with cold filtered raw water to the top of the gage glass.
6. Close the vent valve.
7. Close the vapor valve on the first effect.
8. Open suddenly the steam valve to the first effect coil.
9. Close the steam valve when the cracking ceases, and see that the pressure does not exceed (....) or (....) lb. in the shell.
10. Blow down completely the shell to the waste discharge.
11. Close the blowdown valve.
12. Open the hand valve on the automatic feedwater valve control.
13. See that the shell fills with hot water to the normal running level.

CRACKING DOWN EVAPORATORS—SECOND EFFECT

1. Close the hand valve on the automatic feedwater valve control.
2. Close the vapor valve on the second effect.
3. Open the vent on the low pressure shell.
4. Blow down the shell completely through the blowdown valve.
5. Close the blowdown valve.
6. Fill the second effect evaporator with cold filtered raw water to the top of the gage glass.
7. Close the vent valve.
8. Admit steam suddenly to the second effect coils through the steam line connected to the vapor line. Do not exceed (....) lb. pressure.
9. Close the steam valve when the cracking ceases, and see that the pressure does not exceed (....) lb. on the shell.
10. Blow down completely the shell to the waste discharge.
11. Close the blowdown valve.
12. Open the hand valve on the automatic feedwater valve control.
13. See that the shell fills with hot water to the normal running level.

When putting evaporators in service after cracking down open the vapor valves and proceed according to rules given above for putting an evaporator into service.

MAINTENANCE

Remove the coils from the shells periodically and inspect them for scale formation. If the scale has not been completely removed by the daily cracking down process, remove the coils from the header and clean the tubes and headers by scraping or chemicals as found necessary. Test coil joints for leakage and inspect the evaporator auxiliary heater control valves and float mechanism and clean them when necessary. Tube leakage can be tested for by opening the drains with steam shut off or by raising the water pressure to —— lb. and observing the drain for leakage or abnormal discharge. The interior of shell should be inspected for corrosion, cleaned and when necessary painted. Blowdown valves, safety valves, feed and steam control valves be inspected and overhauled periodically.

PIPING SYSTEMS should be so laid out that pressures at the end of all runs are substantially equal. It is often good economy to take considerable pressure drop in the larger mains so as to use smaller pipe, then allow but little drop in distributing and service branches where a size or two larger pipe in short runs will add little to the total cost of the system.

POWER PLANT ENGINEERING April 15 1932

Features of New Hudson Ave

New Single Shaft Turbine-Generator and Four New Boilers Increase the Capacity of Hudson Ave. by 160,000 Kw. Large Underfeed Stokers and Novel Control Board Are Interesting Features

DURING THE PAST YEAR, power engineers throughout the country have displayed considerable interest in new turbine generator and boiler installation at the Hudson Avenue Station of the Brooklyn Edison Co., for both the boilers and turbines constituting the installation are among the largest of their type in the world.

The entire project includes two 160,000-kw. generating units together with 8 boilers, but at the present time only one-half of this addition has been completed. Unit No. 7, the first of the two new generating units, was placed in commercial service during the latter part of January and since that time has performed remarkably satisfactory.

This generating unit, a single shaft, tandem compound machine, rated at 160,000 kw. and built by the General Electric Co., is, or will be, served by four boilers, two of which went into service with the turbine. A third went in service early in February and the fourth is expected to be completed soon, indeed, by the time this appears in print it will probably be on the line with the others. The erection of these boilers in the comparatively limited space available for storage of material involved engineering difficulties of major importance but they were met remarkably well. Indeed, the story of the erection of these boilers is quite as interesting as a description of the installation itself, but it can only be touched upon here.

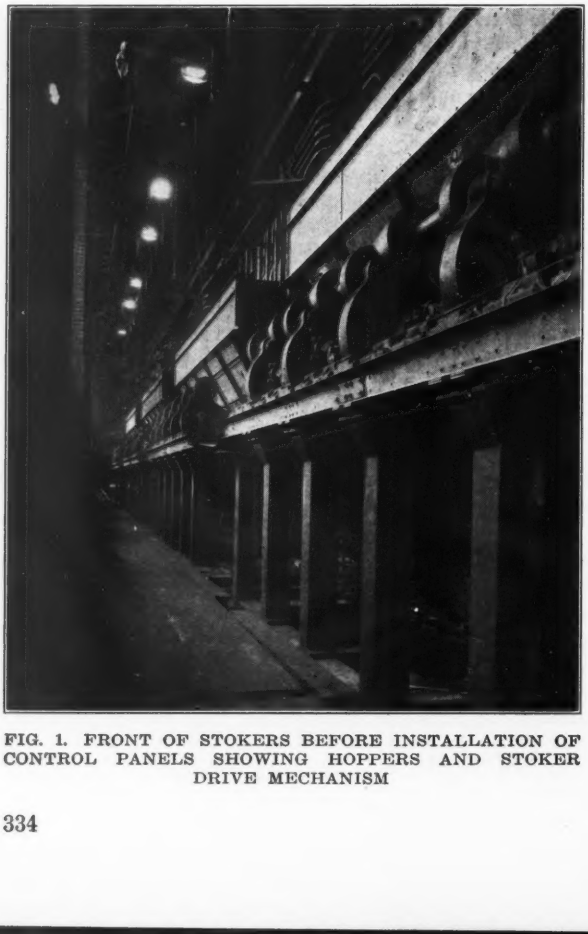


FIG. 1. FRONT OF STOKERS BEFORE INSTALLATION OF CONTROL PANELS SHOWING HOPPERS AND STOKER DRIVE MECHANISM

Each of the four boilers, built by the Combustion Engineering Corp., is designed to deliver 530,000 lb. of steam per hr. at 750 deg. total temperature and 440 lb. pressure. This rating includes the superheater and economizer units. They are fired by the longest stokers in the world, these being Taylor stokers made by American Engineering Co.

Boilers are of the three-drum, bent tube type, each containing 24,450 sq. ft. of heating surface. A fourth, or dry drum, is used as a moisture separator through which all saturated steam must pass before entering the superheater. The latter is of the Elesco hairpin type and has 5,740 sq. ft. of surface. The elements are cantilevered from the superheater headers and pass into the furnace between the first bank of boiler tubes as shown in the accompany cross-section.

Located above each boiler is an economizer with 22,400 sq. ft. of heating surface. The water connections are such as to produce a counter flow arrangement. At full load, the feedwater temperature will be raised 115 deg. with a water pressure drop of 55 lb. The drop loss on the gas side will be 5.5 in. water pressure.

The furnaces are entirely water cooled, each having 3,846 sq. ft. of surface, the greater part of which is comprised of 4-in. finned tubes. Cast iron blocks are cast on to the tubes on the side walls along the fuel bed and on the bridge wall at the ash pit to protect the tubes from erosion. The insulation back of the furnace water wall tubes consists of fire clay tile, 2½-in. blocks of high temperature insulation, 3 in. of rock wool and ½-in. transite panels. The only brick in the furnace is in the side walls above the side water wall headers, and in the small section at the head of the stoker where carborundum is used to help maintain ignition. Each furnace has a volume of 14,000 cu. ft.

Of particular interest in this installation are the Taylor underfeed stokers. The external appearance is quite different from previous units, in that the great length of the unit and the number of secondary rams cause the driving mechanism to be set relatively high above the floor line (6 ft.) so that the clinker grinder

nue Addition

A View Showing the Control and Instrument Panels of the New Stokers

rolls may be set at the proper depth to give good vision of the ash pit from the boiler room floor. Each stoker is capable of burning 57,000 lb. of coal per hr. for a period of two hours, corresponding to a combution rate of 82 lb. per sq. ft. per hr. Each stoker is 15 retorts wide, 69 tuyeres in length and has a projected area of 694 sq. ft. There are six secondary rams for each of the 15 retorts.

Boiler Control Panels Extend Full Width of Stokers

To develop a pleasing appearance in front of the stokers, the boiler control panels were designed to extend the entire width of the stoker with the boiler operating instruments grouped in the center. Advantage was taken of the inspection walkway immediately above the panel for concealed lighting. Access to the secondary ram stroke adjustment rods is gained from the ends of the panels.

In the matter of drive, there was a departure in this stoker installation from the usual practice at Hudson Avenue. Up to the time of installing these units the practice always had been to use direct current motors which received their supply from motor generator sets. Speed control is partly automatic in that the combustion control varies the direct current voltage from the motor generator sets. Further adjustment of speed can be made by the stoker attendant by manually controlling a rheostat in the armature circuit of the motor at each stoker panel. This elaborate speed control has been used because of the wide range and practically infinite number of speeds afforded by it.

For the new units, however, alternating current drive has been provided. Here a Hele-Shaw hydraulic drive is used. A constant speed squirrel cage motor drives a variable displacement radial oil pump, the discharge from which flows at pressure varying from 400 to 800 lb., to a similar radial hydraulic motor unit mechanically connected to the main stoker drive shaft. An electric pilot motor regulated by automatic combustion control is used to vary the position of the cylinder blocks in the oil pump and thus change the piston stroke or oil displacement.

For removal of ash, the Allen-Sherman-Hoff high pressure sluice system is used. When the ash passes through the clinker grinder rolls it drops into a sealed brick lined storage hopper, from which the sluicing system delivers it to an ash pit on the wharf. One of the three hydraulically operated vertical gates is opened at a time and the feed plate located at the bottom of the hopper is swept by a movable jet, the water leaving the jet at 100 lb. pressure.

As shown in the cross section, the forced draft fans are located in the basement. These feed into a trunk duct from which the stokers take their air, each stoker connection having a damper which is automatically operated to compensate for variations in fuel bed thickness and pressure loss along the duct.

Each forced draft fan is designed to deliver 200,000 c.f.m. against a static pressure of 10 in. and is driven by a 500-hp. motor. Air discharge from the fans is regulated without changing their speed by adjustable vanes mounted around the fan inlet and operated by the automatic combustion control. As the opening of the vanes is varied the rotative speed of the incoming air with respect to the rotor speed is varied, causing a change in the fan pressure, volume, horsepower and efficiency characteristics. This method of control is far more efficient than throttling with a discharge damper, and when initial investment is considered it is superior to adjustable speed control.

One of the astonishing things one learns in visiting the induced draft fan floor at Hudson Ave. is that the motor capacity for the induced draft fans for the eight new boilers amounts to 16,000 hp.! Each boiler unit has two induced draft fans, each of which is driven by a 1000-hp. motor provided with three windings to give speeds of 1160, 870 and 580 r.p.m. The fans are designed to deliver 155,000 c.f.m. against 20 in. static pressure, and are equipped with vane control.

To remove dust from the flue gas, cinder catchers are used in each of the new boiler uptakes. The type of

cinder catcher used is one which was developed jointly by the operating and mechanical engineering departments and which after exhaustive tests has been shown to be highly efficient and no more costly than any apparatus available. It consists of a large cast iron hopper filled with salt water, with alternate 1¼ in. and 3¾ in. gas inlet and outlet passages approaching the surface of the water perpendicularly. The narrow gas inlet passages produce a series of high velocity jets which project the cinder into the water. The gas velocity drops after leaving the water surface due to the larger outlet passages and further separation of cinder from the gas takes place. Because of the high inlet gas velocity, considerable wave action is produced on the water surface.

know a few facts regarding the erection of this equipment. In order to meet the conditions imposed by limitations in storage space, it was necessary for shipments of material to be scheduled very carefully and that the plants shipping the material adhere strictly to schedule so that the erection crews would be able to plan their work in such a way that as soon as material was received, it could be unloaded, removed and erected in place. The position of the boiler house with relation to the dock was such that a truck could not operate efficiently in unloading lighters due to short haul. Consequently all material with the exception of the boiler, drums and a few of the heavier headers which were pulled in on skids, had to be handled manually.

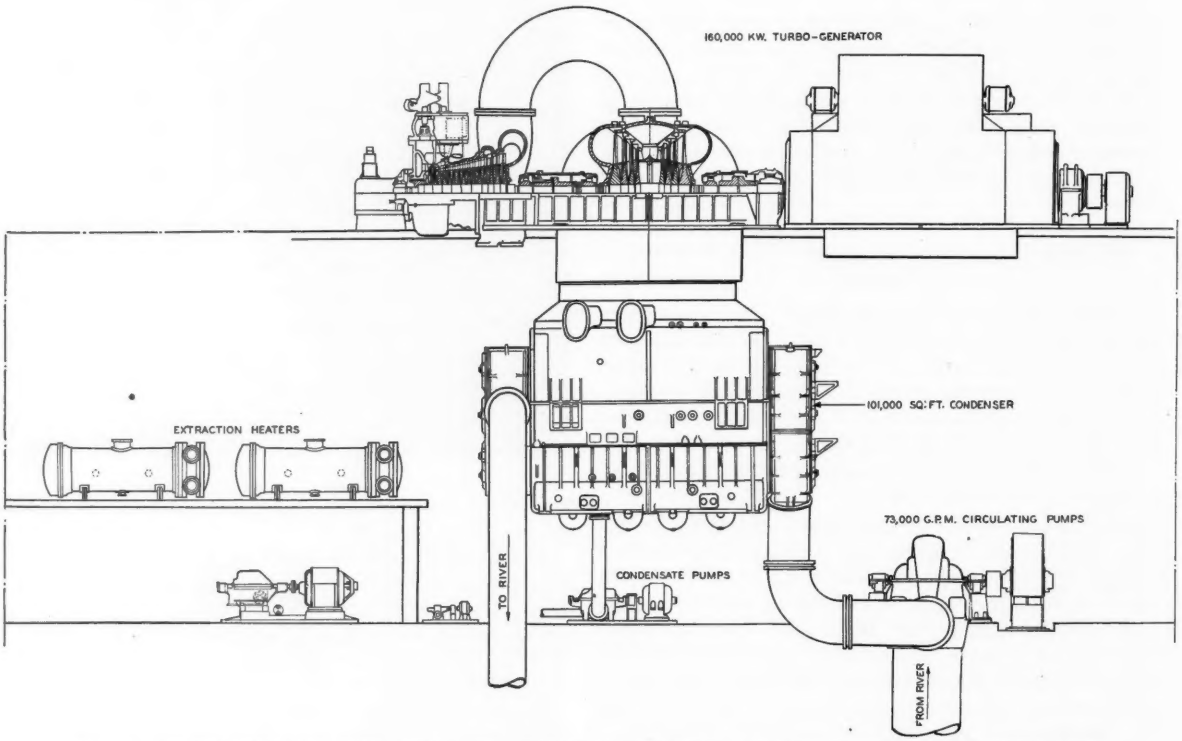


FIG. 3. ELEVATION OF THE 160,000-KW. TURBO-GENERATOR AND CONDENSER AT HUDSON AVE.

This is minimized by a series of splash plates which run lengthwise of the hopper, and project above and below the water line. After considerable experimenting and service trials with many materials, ebony asbestos has been selected for the splash plates. Cast iron or steel does not last six months in this service, being attacked by the acidic condition of the water. To prevent an accumulation of floating cinder sludge, make-up water is jetted onto the surface continuously between splash plates and is taken off at the center over a weir extending the entire width of the hopper. The cinder which settles to the bottom of the hopper is sluiced out when desired by high pressure jets in the hopper bottom. Corrosion of the cinder catcher elements is minimized by using enameled Armco iron and protecting the bottom section of the gas inlet and all the gas outlet passages with an acid resisting enamel.

These are the essential features of the boiler installation. Before proceeding with a description of the turbine and condenser installation it may be of interest to

Despite these difficulties, everything was handled perfectly on schedule. Careful planning was followed throughout, all erection units synchronized so that at no time did any material accumulate during the period of erection.

Turbogenerator Installation

Turbogenerator No. 7, the first of the two new units, is rated at 160,000 kw., 80 per cent power factor, 16,500 v., one of the largest single shaft units in the world. The turbine consists of two cylinders, the high pressure unit operating at 400 lb. per sq. in. gage and the low pressure at from 3 to 13.4 lb. per sq. in. absolute, depending on the load. At full load, the high-pressure cylinder develops 120,000 of the 160,000 kw. There are eight governing valves and five valve points, the primary, quarternary and quinary being in pairs. The high-pressure cylinder has 15 stages and is bled from two points, one located between the eleventh and twelfth stages at a pressure varying from 11 lb. to 49 lb. per

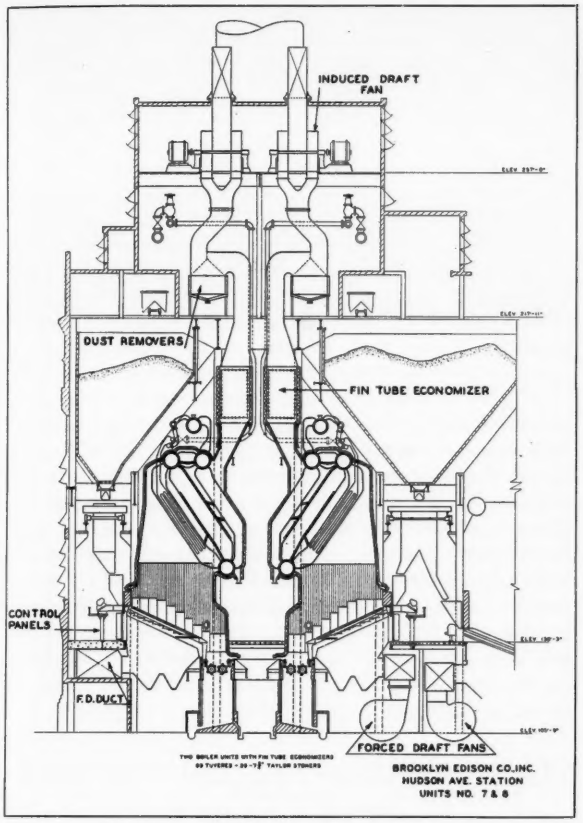


FIG. 4. SECTION SHOWING DETAILS OF THE NEW BOILERS

square inch absolute, and one at the exhaust end at a pressure varying from 3 lb. to 13.4 lb. per square inch absolute over the operating range. The low pressure unit is of the double flow design with four stages in each end. The last wheel has a diameter of 12 ft. 9½ in. and a top speed of 1205 ft. per sec., or 821 mi. per hr.

The turbine is designed to carry full load at the hottest condenser water which can be expected in summer time—that is, on a 27.5-in. vacuum.

The blades are of Ascolloy, those in the last stage being 39 in. long. For the first time in turbine design special provisions have been made to drain moisture

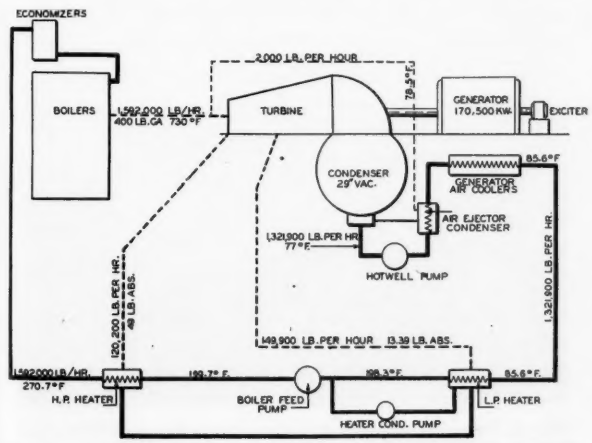


FIG. 5. A HEAT BALANCE DIAGRAM FOR THE NEW UNIT

from every stage of the low-pressure cylinder in an attempt to reduce the blade and condenser tube erosion. The recesses which collect the moisture thrown out by centrifugal force drain to the condenser. An attempt will be made to determine the effectiveness of the drains during the acceptance tests by measuring the quantity of water removed.

To obtain a heat balance, the condensate leaving the hotwell is pumped by the main condensate pumps through the air ejector condensers, the generator air coolers, and low-pressure heater in the order named. At the discharge of the low-pressure heater the boiler feed pumps raise the pressure to 600 lb. and pass the water through the high-pressure heater and economizer to the boiler drum. The condensate from the high-pressure heater is passed through a trap and flashed into the low-pressure heater to be condensed with the low-pressure heater steam and passed to the heater condensate pumps which lift the water to the boiler feed pump suction pressure.

Because of the space requirements for condenser tube withdrawal, the generator air coolers had to be located above the floor on the sides of the generator frame. Instruments are mounted on the outside of the cases to indicate the temperature of the ventilating fan bearings which are inaccessible when the machine is in operation.

The condenser was built by the Worthington company and is the largest single-shell, single-pass condenser in operation. The condensing surface area is 101,000 sq. ft. and is designed to maintain 27¾-in. vacuum when condensing 1,320,000 lb. steam per hour with 73 deg. F. circulating water and 70 per cent tube cleanliness. The tube sheet layout follows the Worthington "folded layer" design. The unit contains approximately 84 mi. of tubing made up of 14,710 30-ft. ⅞-in. outside diameter Admiralty tubes. The tube sheets, tube support plates and internal baffles are of Muntz metal. Air is taken off through two 10-in. connections, one in each side of the shell to a precooler, and then through two stages of ejection to atmosphere.

Each of the two circulating pumps will deliver 73,000 g.p.m. at a maximum speed of 220 r.p.m. and is driven by a two speed 225/164-r.p.m. motor rated at 600 hp. at the higher speed.

OF THE RECORDED water power resources in Canada, which, according to the latest estimate, is sufficient to generate 43,700,000 hp., only 15½ per cent or 6,666,337 hp. are as yet developed, according to information reaching the Natural Resources Department of the Canadian National Railways. The capital invested in development of this power, including transmission and distributing systems totals more than $1,514,000,000, a greater amount than is invested in any other industry in the Dominion. Of the total power installed for all purposes, over 80 per cent is produced by water.

AT HASTINGS (Eng.) station, transformers set in oil-filled, steel-plate tanks holding 5100 gal., which have fin radiator tubes are cooled by natural air circulation up to half load, 7500 kv-a. For higher loads, forced circulation is employed, a 5½-hp., 440-v., squirrel-cage motor driving a fan at 970 r.p.m. to deliver 17,650 cu. ft. air per min. at 1.44 in. water pressure. The oil is normally circulated at 110 g.p.m. through the cooler but can be increased to 125 g.p.m. maximum.

Power Utilization

Induction Motor Operation

By Edward W. Johnston

REFERRING to the problem on p. 183 of Feb. 15 issue, a typical slip-torque curve of an induction motor shown in Fig. 1 reveals that, for small values of slip up to and beyond full load, the torque is substantially proportional to the slip.

Small starting torque is due to the reactance of the stator and the rotor. The rotor reactance is proportional to the rotor frequency, ($X_2 = 2\pi f_2 L_2$). The rotor frequency f_2 is proportional to the slip. As the rotor slip increases, the rotor reactance increases proportionally, whereas the resistance change is negligible. The effect of this is to increase phase difference between the rotor currents and their induced voltages. As these currents

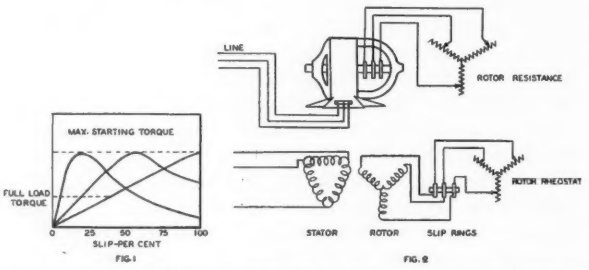


FIG. 1. VARIATION OF TORQUE AND SLIP WITH ROTOR RESISTANCE
FIG. 2. CONNECTION OF RESISTANCE INTO ROTOR CIRCUITS

at the same time differ in space phase with the flux, less torque per ampere is developed. In fact the current and the flux may become so far out of space phase with each other that, even with four or five times the rated current, only a small fraction of the full load torque is developed.

For a given value of torque, a definite value of flux and a definite value of rotor current are required. Counter-electromotive-force in the stator of an induction motor is practically constant, hence flux is practically constant. When resistance is introduced into the rotor circuit, the impedance of that circuit tends to increase and current to decrease; hence torque will diminish, if slip remains constant.

Rotor current must be increased in order to bring the torque back to its original value and increase of induced e.m.f. needed to increase current in the rotor may be obtained by the flux cutting the rotor's conductors at a greater rate, since the flux is constant. Thus to produce a given value of torque, the slip must increase when resistance is introduced in the rotor circuit.

Position of the slip-torque curve will be changed from say A to B in Fig. 1. As the rotor resistance is increased, full load torque is obtained at greater values of slip. It should be noted that the value of maximum or breakdown torque, which nearly equals $KE^2 \div X_2$ will not be affected but the point of maximum torque moves towards the point of zero speed, where slip is 100 per cent. By referring to C in Fig. 1, it will be seen that, if sufficient resistance is introduced in the rotor circuit, maximum torque may be made to occur at standstill; in other words, breakdown torque is obtained at starting. In order to obtain breakdown torque at starting, the rotor resistance per phase should be equal to the rotor reactance per phase at standstill, X_2.

Figure 2 shows the connections for a wound-rotor induction motor with three ends of the three-phase windings brought out to the three slip rings. Brushes bearing on these three rings connect to Y-connected external resistances. At starting, the entire resistance of each phase is in circuit. This causes the rotor current to be more nearly in space phase with the air gap flux, so that a large torque is obtained with moderate value of current. Not only is a good starting torque produced in this way but the starting current of the motor will but little exceed the rated current. As the motor comes up to speed, the external resistance is cut out and the motor operates on curve A, Fig. 1.

Convertible Tractor Shovels and Cranes

For Unloading Coal, Handling Ashes and Maintenance Work. By C. E. Kohl*

DURING the past few years, the power plant field has adapted equipment for a diversity of material handling problems such as unloading coal from cars, handling ashes and miscellaneous traction and hoisting around both the power plant proper and the industrial plant.

Since a shovel of ⅜ or ½ yd. capacity will handle from 600 to 1000 cu. yd. of material such as coal in a day, it will care for the requirements of a fairly good sized plant. In about an hour's time the standard dipper and dipper boom can be removed and a crane boom with clam shell attachment installed, so that the shovel becomes available for handling of a wide variety of bulk materials, unloading from cars to stock pile, loading from stock pile to dump cars, trucks, or conveyors.

*Crane & Shovel Engineer, Austin Manufacturing Co.

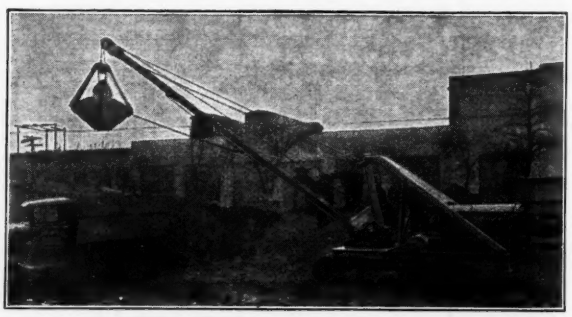


FIG. 1. THREE-EIGHTHS YARD SHOVEL HANDLES COAL FROM STORAGE TO TRUCK

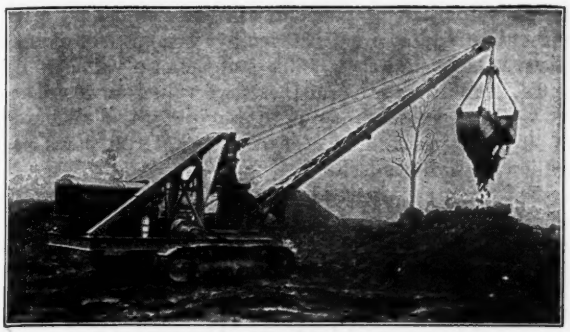


FIG. 2. CRANE BOOM AND CLAM SHELL, SERVES FOR UNLOADING COAL OR LOADING ASHES

Most useful as an attachment for a small tractor shovel is the crane with a telescopic boom equipped with a sheave hook block. Such a boom may be about 25 ft. long with a 10-ft. telescopic extension giving a 35-ft. reach. Although capacities vary greatly, when converted as a crane, a ⅜-yd. shovel will handle loads of approximately 3000 lb. at a radius of 15 ft. Where the boom is almost vertical and the entire machine is moved on the tractors, the load can be increased somewhat beyond that limit. In this way erection work such as boiler setting is handled.

Availability of the tractor crane around a plant is illustrated by the renewing of wheels on an overhead crane. Ordinarily the crane must be blocked up on its track—a rather awkward job due to its height from the floor and the limited working area of the I-beam track. Here the tractor crane can be brought in and, with the boom in a vertical position, a sling is thrown around one end of the overhead crane, which is raised sufficiently to permit changing the wheels; the operation is repeated at the other end, simplifying a comparatively difficult job.

For trimming up stock piles or for grading filled in land the drag line attachment is often useful. In building up dikes, as a protection against floods or around oil tanks, the drag line can be used when a foot or two of the surrounding surface can be utilized to provide the material for the dike.

In excavating problems around the average plant,

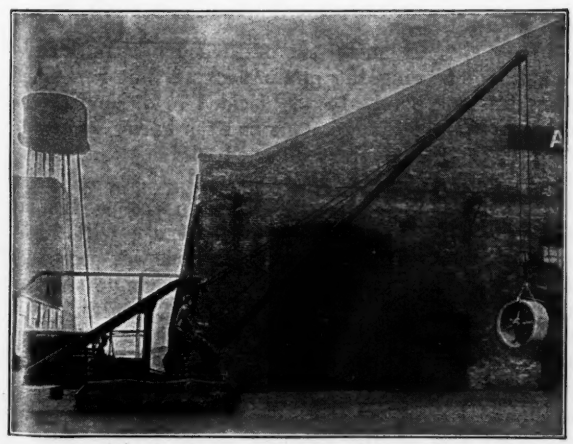


FIG. 3. CRANE BOOM AND PULLEY BLOCK ARE USED FOR MAINTENANCE WORK SUCH AS RENEWING BOILER SETTINGS OR MISCELLANEOUS MATERIAL HANDLING

the convertible shovel comes into play. When equipped with a trench hoe the shovel can be used for digging trenches up to 14-ft. in depth and for digging and cleaning ditches up to 20-ft. in width at the top. Extension of the field of work for the convertible shovel is due to the attachments which manufacturers have provided and to mechanical improvements, which have increased reliability, flexibility, portability, also reduced maintenance and operating costs. This latter point is in part due to the use of heavy anti-friction bearings at every point of consequence, the reduction in friction losses having brought about a definite reduction in the size of the power plant required.

Other mechanical refinements are interchangeable booster-type clutches, readily renewable brakes, high-pressure lubrication of all points and a greater degree of accessibility. Cut gearing, enclosed and running in oil, is another design feature now utilized in small shovels.

Tractor speeds as high as 4 mi. an hour on the road are now obtainable although it is the usual practice to provide a mounting of rubber-tired wheels for quick transportation and tow the shovel behind a truck. With such a mounting it is possible to transport a shovel at a speed of 25 mi. an hour from job to job. By utilizing the power of the crawlers and with suitable blocks, it is possible to mount the shovel on its wheels in approximately 10 min. and to demount it in 5 min.

Alkalinity Determination Chart

By Norbert W. Sager

AS A MEANS of checking the performance of a water softener in which lime is used as one of the reagents, resort is usually had to certain relatively simple routine chemical tests which indicate the total alkalinity of the water and the distribution of the forms of this alkalinity in terms of bicarbonates, carbonates and hydroxides. In order to determine this distribution, a table similar to the following is used in which M is the alkalinity shown by the quantity of standard acid required in the analysis to reach the methyl orange end point, and P is the alkalinity for the quantity of acid required to reach the phenolphthalein end point, each in parts per million.

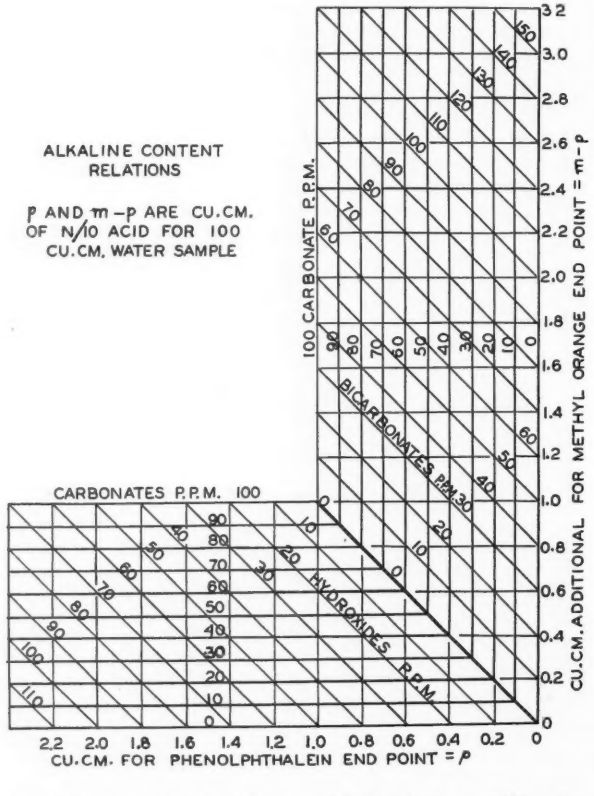
If 100 c.c. of water is used for the test and sulphuric acid N/10 or one-tenth normal strength for the titrations, then alkalinity P will be 50 times the cubic centimeters of acid used in the phenolphthalein test and alkalinity M will be 50 times the c. c. of acid for the methyl orange test. Usually the test is made by adding a few drops of phenolphthalein to the 100 c. c. of water to be tested. If water stays white, no carbonates or hydroxides are present and P = zero. If water turns red, acid is added while stirring until color changes back to white and the cubic centimeters used p are noted. P alkalinity will be this amount times 50, or $50p$.

To the same sample, 2 to 4 drops of methyl orange are added. This will give a yellow color and acid is added until this turns to faint pink. The sum of the cubic centimeters of acid thus used, m-p plus those for

the phenolpthalein test, p multiplied by 50 gives the alkalinity M. $M = 50(m\text{-}p + p)$.

	Bicarbonates P.P.M. =	Carbonates P.P.M. =	Hyperoxides P.P.M. =
P = O	M	0	0
P less than ½M.	M-2P	2P	0
P = ½M	0	2P	0
P greater than ½M	0	2(M-P)	2P-M
P = M	0	0	M

The simplicity and ease with which this table may be used is not questioned but it was felt that the gamut of results as shown by the above table could easily be



plotted on a chart which would further simplify the task of finding the distribution of alkalinity forms in a sample of water. With this in mind the accompanying chart was constructed.

The chart is based on the use of a 100 c.c. sample of water and the use of one-tenth normal strength acid, N/10, for titrating. The horizontal or p scale represents the number of c.c. of acid required to reach the phenolphthalein end point, while the vertical or m-p scale represents the additional number of c. c. of acid required to reach the methyl orange end point. Of course the sum of the two quantities thus determined, $p + (m\text{-}p)$ equals the acid required for the total alkalinity end point, or m.

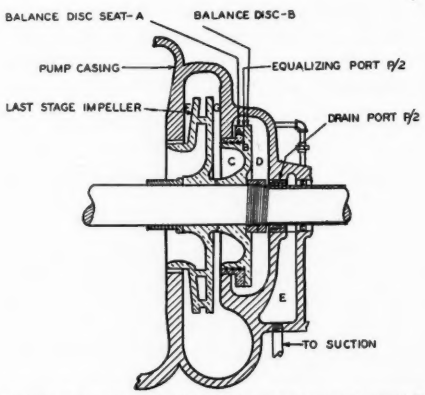
In using the chart the p value and the m-p value as determined from the titrations are intersected on the chart. The point of intersection immediately gives the quantities of the various forms of alkalinity. To illustrate: Suppose that with a 100-c.c. sample of water, 0.8, c.c. of one-tenth normal acid were required to reach the phenolphthalein end point and 0.4 c.c. of acid more were required to reach the methyl orange end point. The p value would then be 0.8 and the m-p value would be 0.4. The intersection of these two values on the chart shows that the alkalinity of the sample was distributed as 40 parts per million of carbonate and 20 parts per million of hydroxide.

The chart may be readily adapted for use with water samples of a size different from 100 c.c. or for standard acid of a strength different from tenth normal simply by changing the magnitude of the scale figures used.

Pump Rotor Trouble

By Grady H. Emerson

SEVERAL MONTHS ago a customer called up with the complaint that a motor which had just been rewound was getting so abnormally hot that, after a few minutes' operation, the rotor and winding would smoke. This condition of operation, as the manager of the mine knew, would soon burn out the winding. As the



DETAILS OF BALANCING DISC AND SEAT

motor had just been overhauled, he did not allow his electrician to work on the motor.

I took to the mine an ammeter and current transformer. The motor was 40-hp., 2200-v., 3-phase induction, whose full load current should not have been over 12 amp. It was started and the meter read from 30 to 40 amp., showing that the motor was drawing an excessive current.

When shut down, the motor turned by hand freely enough, considering the pump packing, but it seemed to bind at one point. It was decided to disconnect the coupling. When this was done and the halves separated about ¼ in., the motor was started without load, taking about 3 amp.

Next the upper part of the pump casing was removed. The pump was of standard make with automatic balancing disc arrangement, which was necessary because of three stage construction and single suction. Although the pump had just been overhauled and was supposed to be in perfect running condition, we found the impellers worn almost to a knife edge on the side nearest the suction. The balancing disc was cut almost through. Looking for the cause of this abnormal wear, we found that in the chamber shown on the accompanying sketch at E the suction had been plugged up. Also the hole where this connecting pipe entered

the suction chamber had been plugged. This was not such an absurd mistake for a mechanic to make who was unfamiliar with centrifugal pumps but it was costly in this instance.

Why this would cause the destruction of impellers and wearing rings may be seen by studying the sketch, showing cross section of the last stage and balancing disc. Difference of total pressure exists on the faces of the impeller due to the difference between the areas of surfaces F and G. This is, of course, caused by the hub of the impeller. To offset this and prevent the pump rotor being forced against the wearing rings and casing, with abnormal friction wear, a balancing disc is keyed to the shaft, shown at B and a seat is provided at A.

The last stage pressure on the balancing disc in the chamber forces the opening at port P_1 open, which releases the pressure somewhat so that the port tends to reclose. Pressures are soon equalized and the pump is automatically balanced without the use of heavy thrust bearings. As P_1 opens, drain port P_2 is closed and the pressure in chamber D rises to equal pressure in chamber C. Working on the larger surface, this pressure forces the impeller toward the suction. Pressure in D is relieved by draining out at P_2 and through the suction pipe leading out the bottom of chamber E. When this pipe was plugged, the pressure having no relief built up and forced the impeller into contact with the wearing rings, with resulting terrific wear.

This incident illustrates how quickly trouble on equipment may be located by a few simple measurements.

It took about 40 min. but if no instruments had been available, probably the motor windings would have been checked and maybe numerous other unnecessary things done before opening the pump. The fact that the pump had just been overhauled would also have convicted the motor under ordinary circumstances.

Keeping an Oil Pipe Warm

By George P. Pearce

ONE COLD, SNAPPY morning, Bill found he could not get his new oil furnace started; in fact, there seemed to be no oil. He glanced across the 50-ft. space to the big forge shop and noticed that the furnaces there were running OK. Finally, after a little investigation, Bill found that the reason for the absence of fuel was because the oil supply pipe in the trench connecting the two buildings had cooled to below the congealing point of the oil. Thereupon Bill notified the millwright department and they packed hot sand bags around the insulated pipe until, after a 3-hr. delay, the heat finally penetrated into the oil and the furnace was got into production. This satisfied Bill but not the superintendent, who immediately ordered the master mechanic to do something so that this 50-ft. run would never freeze up again.

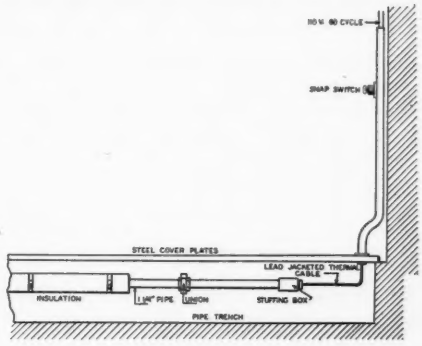
Investigation showed the master mechanic that the oil line was 1¼-in. pipe covered with standard pipe covering. It ran through a concrete trench of ample dimensions, with sheet metal cover plates, and connected with the forge shop. In the forge shop, the line was connected to the main oil line and from this point the oil was always warm, as the forge shop main was a circulation system. The line to Bill's small repair shop was dead end with no provision to warm the oil in it. As the nearest steam line was almost 1000 ft. away, the master mechanic had a real problem on his hands so he hunted up the mechanical engineer and told him about the mess.

"You see, Jack," the master mechanic said, "it's going to take over 2000 ft. of pipe to get a steam line into that trench and return the condensate and then we would also have to reinsulate the oil line in order to include the steam pipe."

"That won't work, anyhow, because we must not get the fuel oil above 180 deg. for, if we do, gas pockets will be formed, some of the oil will 'crack' and probably fill up the pipe with carbon."

"The supe said: 'Fix it so it won't freeze up again, and if there's no other way I'll put in a special hot water system to look after the job.' Nothing was said about the cost.

"Well, that won't work either," answered the mechanical engineer, "because you can't spend more than



ELECTRIC HEATING OF OIL PIPE

$200 without my ok, and you know I'm not going to pass anything like that. Suppose we first of all find out how much heat is going to be needed to keep that line at 100 deg. On a zero night that would mean a temperature difference of just 100 deg. between the oil and the outside of the insulation. Now standard pipe covering will radiate 29 B.t.u. per hour per foot for the 1¼-in. size when the temperature difference is 100 deg. That figure, however, is based upon test conditions so we had better allow an extra 25 per cent for poor joints, fittings and errors," continued the mechanical engineer, getting his slide rule to find the new figure. "That will make 36 B.t.u. per foot per hour as the amount of heat we will have to put into that oil for a couple of hours or so before Bill arrives on the job to make sure there will be no more trouble."

"Thanks, Jack. That solves the problem nicely. Now just tell me how to deliver that amount of heat and distribute it uniformly."

"Getting sarcastic, eh! Well, there are electric lights in Bill's shop, so maybe we can put an electric heater in the pipe and let that do the trick. Let's see; we'll have to use $36 \times 0.2928 = 10.55$ watts per foot and for the 50 ft. we would have to supply $10.55 \times 50 = 527.5$ watts. This would mean, for 110-v. circuit, a resistance equal to the voltage squared divided by the watts or $12{,}100 \div 527.5 = 23$ ohms. Dividing this by 50 gives us about 0.5 ohms per foot run and that is just about the resistance of a No. 19 Nichrome wire."

"Say, that's a good idea. We'll string thermocouple

insulators along the 50-ft. length of No. 19 Nichrome wire. Then we'll insulate the ends, band the whole business to the 1¼-in. pipe and then reinsulate ——"

"Wait a minute," interrupted the M. E. "There's no need to go to all that expense. We can just buy 50 ft. of lead jacketed thermal wire, such as some farmers use for hot beds and ground the resistance wire to the lead jacket at the end. Then all you need do is to push this cable into the oil pipe from the dead end and seal it by a stuffing box plug like this," and he made the sketch shown.

"Say, that'll do the trick fine," admitted the M. M. grinning, "and it'll cost hardly anything to install as we shall not have to touch the present insulation or even open up the trench except the end in Bill's place. For a few cents worth of electricity we can warm up the oil and Bill can snap off the switch as soon as he gets his furnace running. But say, how about using that lead jacket for a return? There'll be a short circuit, won't there, everywhere the lead jacket touches the iron pipe?"

"Not if you instruct your electrician to be sure and connect that end to the grounded side of the line. All our lighting circuits are grounded on one side, you know."

"Thanks, Jack. I'll have that line fixed up by quitting time tonight. You know you're real useful, sometimes."

Voltage Drop Calculation Curves

By Vernon W. Palen

FREQUENTLY the author has had occasion to make voltage drop calculations for loads having different power factors. The frequent necessity of computing these drops led to the development of a convenient set of curves shown herewith as Fig. 1, A, B, C, D, E and F. The curves take care of the usual varieties of overhead

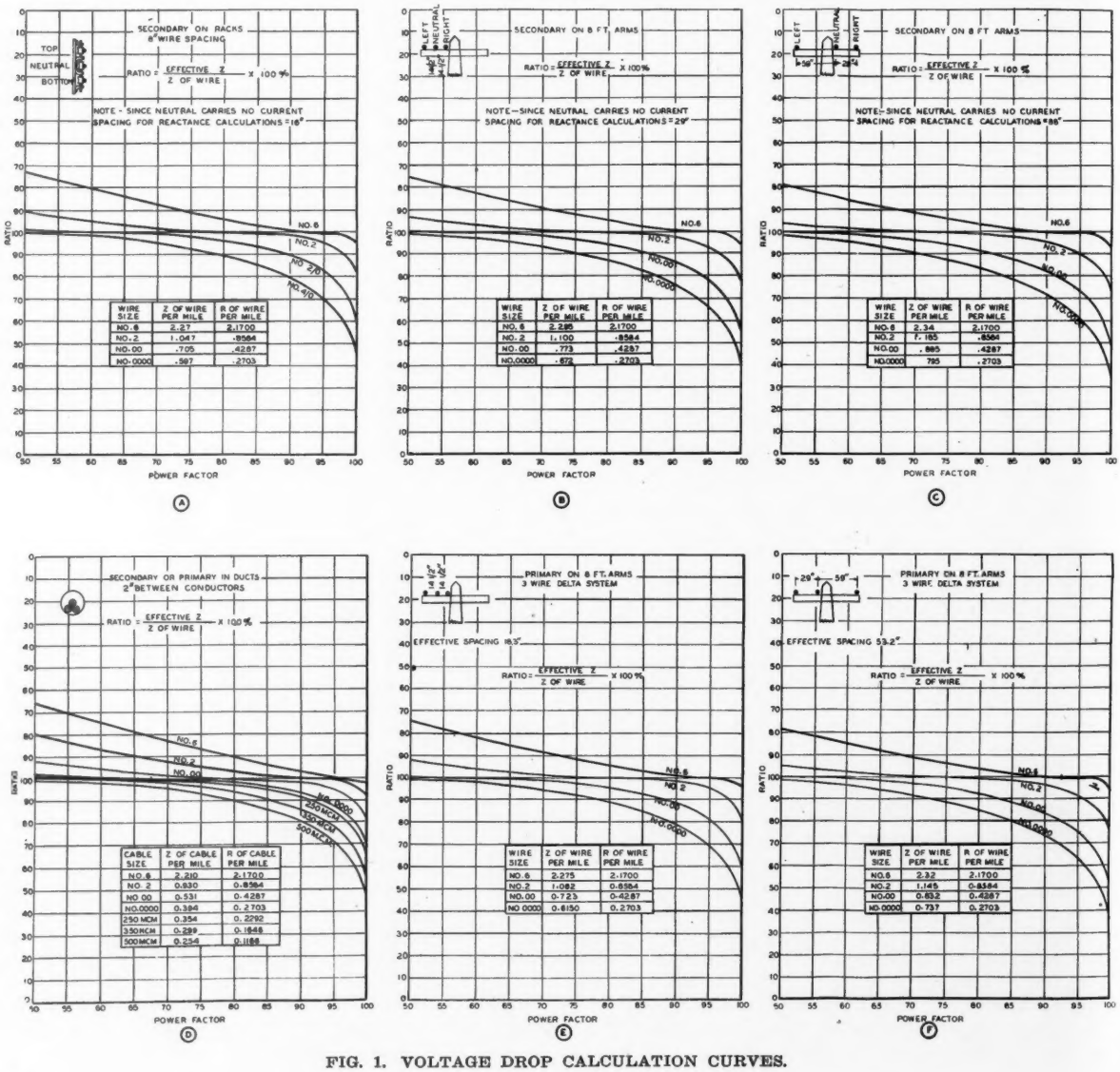

SECONDARY ON RACKS 8" WIRE SPACING
TOP NEUTRAL BOTTOM
RATIO = EFFECTIVE Z / Z OF WIRE X 100 %
NOTE - SINCE NEUTRAL CARRIES NO CURRENT SPACING FOR REACTANCE CALCULATIONS = 16"
WIRE SIZE | Z OF WIRE PER MILE | R OF WIRE PER MILE
NO. 6 | 2.27 | 2.1700
NO. 2 | 1.047 | .8584
NO. 00 | .705 | .4287
NO. 0000 | .597 | .2703
RATIO
POWER FACTOR
A
SECONDARY ON 8 FT. ARMS
LEFT NEUTRAL RIGHT
RATIO = EFFECTIVE Z / Z OF WIRE X 100%
NOTE—SINCE NEUTRAL CARRIES NO CURRENT SPACING FOR REACTANCE CALCULATIONS = 29"
WIRE SIZE | Z OF WIRE PER MILE | R OF WIRE PER MILE
NO. 6 | 2.295 | 2.1700
NO. 2 | 1.100 | .8584
NO. 00 | .773 | .4287
NO. 0000 | .672 | .2703
RATIO
POWER FACTOR
B
SECONDARY ON 8 FT. ARMS
LEFT NEUTRAL RIGHT
RATIO = EFFECTIVE Z / Z OF WIRE X 100 %
NOTE-SINCE NEUTRAL CARRIES NO CURRENT SPACING FOR REACTANCE CALCULATIONS = 86"
WIRE SIZE | Z OF WIRE PER MILE | R OF WIRE PER MILE
NO. 6 | 2.34 | 2.1700
NO. 2 | 1.185 | .8584
NO. 00 | .885 | .4287
NO. 0000 | 795 | .2703
RATIO
POWER FACTOR
C
SECONDARY OR PRIMARY IN DUCTS 2" BETWEEN CONDUCTORS
RATIO = EFFECTIVE Z / Z OF WIRE X 100 %
CABLE SIZE | Z OF CABLE PER MILE | R OF CABLE PER MILE
NO. 6 | 2.210 | 2.1700
NO. 2 | 0.830 | 0.8584
NO 00 | 0.531 | 0.4287
NO 0000 | 0.384 | 0.2703
250 MCM | 0.354 | 0.2292
350 MCM | 0.299 | 0.1848
500 MCM | 0.254 | 0.1188
RATIO
POWER FACTOR
D
PRIMARY ON 8 FT. ARMS 3 WIRE DELTA SYSTEM
EFFECTIVE SPACING 16.3"
RATIO = EFFECTIVE Z / Z OF WIRE X 100 %
WIRE SIZE | Z OF WIRE PER MILE | R OF WIRE PER MILE
NO. 6 | 2.275 | 2.1700
NO. 2 | 1.082 | 0.8584
NO. 00 | 0.723 | 0.4287
NO 0000 | 0.6150 | 0.2703
RATIO
POWER FACTOR
E
PRIMARY ON 8 FT. ARMS 3 WIRE DELTA SYSTEM
EFFECTIVE SPACING 53.2"
RATIO = EFFECTIVE Z / Z OF WIRE X 100 %
WIRE SIZE | Z OF WIRE PER MILE | R OF WIRE PER MILE
NO. 6 | 2.32 | 2.1700
NO. 2 | 1.145 | 0.8584
NO. 00 | 0.832 | 0.4287
NO 0000 | 0.737 | 0.2703
RATIO
POWER FACTOR
F

FIG. 1. VOLTAGE DROP CALCULATION CURVES.

construction for both secondary and primary (delta system).

It will be well to outline the theory underlying these curves, since readers may care to develop similar curves to meet other conditions.

Figure 2 shows a typical vector diagram (exaggerated) of voltage drop in a given line.

B is the angle between ZI and RI =

$$\text{angle whose cosine} = \frac{RI}{ZI} = \frac{R}{Z}.$$

θ = power factor angle = angle whose cosine = P.F.

Since, for practical purposes, the effective drop is the projection of ZI on PO we must subtract C from B (in degrees) to get the angle A. Then Z (cosine A) = effective Z. This value will never be greater than Z and usually will be less than Z, depending on the power factor of the load. The ratios of

$$\frac{\text{Effective Z}}{\text{Z of wire}} \times 100 \text{ per cent}$$

are the values shown by the curves for various wire spacings and for load power factors of 50 to 100 per cent.

FIG. 2. VECTOR DIAGRAM OF VOLTAGE DROP IN A GIVEN LINE.

In order to compute the drop in any line constructed as shown on any one of the six curve sheets, it is merely necessary to refer to that particular sheet for the correct value of Z to use. Thus we see that for a No. 0000 wire on secondary racks at 90 per cent power factor, we should use 80 per cent of the value for Z of the wire.

Effective Z will therefore be:

$$0.80 \times 0.597 = 0.478 \text{ ohms per mile.}$$

The value above (0.478) is then used in the usual manner in the formula

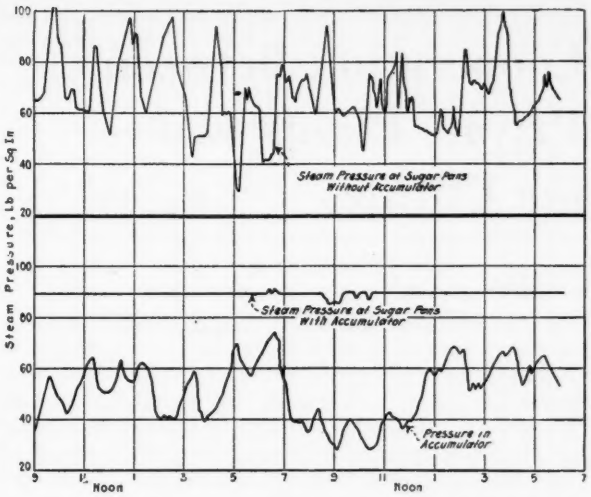
$$\text{Drop} = IZ.$$

Where Z is the effective value, which takes account of load power factor instead of Z of wire, which does not take account of load power factor.

It would be a simple matter to go one step farther and develop curves showing effective Z plotted against power factor, however, the author felt that this was not justified since it takes but a few seconds to select the correct factor from the curves shown and to multiply it by the correct Z of the wire (also shown on the curve sheet).

Accumulators for Heat Storage

ONE OF THE MOST important factors in the operation of an industrial power plant is that of properly coördinating the process steam load with the electrical load. A number of methods for accomplishing this are available; among them the use of bleeder or mixed pressure turbines, but few of them, perhaps, are as simple and effective as that using the steam accumulator.


Steam Pressure, Lb per Sq In
Steam Pressure at Sugar Pans Without Accumulator
Steam Pressure at Sugar Pans With Accumulator
Pressure in Accumulator
Noon
Noon

RESULTS IN STEADYING PRESSURE BY THE USE OF A STEAM ACCUMULATOR IN A SUGAR REFINERY

The steam accumulator may be thought of as a flywheel, a balance wheel, between the boilers and the steam using equipment in the plant. Its function is to store steam at a time when the requirements are low and generate or release it at times when the requirements are high. In its simplest form, a steam accumulator consists of a large drum or shell, well insulated against loss of heat and provided with suitable automatic valves to control and regulate the steam and water supply. When used in connection with a low pressure turbine, the excess steam from the supply flows into the accumulator where it condenses and the heat absorbed by the water. This occurs under increasing pressure and keeps the water near the temperature of saturation. When the steam supply ceases, the steam pressure decreases and as a result a part of the hot water vaporizes and flashes into steam. Thus, a continuous supply of steam is available for the low pressure turbine. The pressure gradually decreases until the high pressure turbine or other steam producing equipment again begins to furnish steam.

In practice, the accumulator may be used in three different ways. 1. Where only process steam is used, to steady the demands on the boiler plant. 2. Where power is generated and exhaust steam used for process work, floating on the system to equalize between power and process requirements. 3. Where two process pressures are used, and the accumulator is used to act as a balance between the two process demands, at the same time serving as a flywheel to steady the boiler load by taking overflow steam throttled to the higher process pressures.

Perhaps the best way of showing the effectiveness of the use of a steam accumulator is by means of a curve such as that in the accompanying illustration. This shows the results in steadying pressure by the use of an accumulator in a sugar refinery. The upper curve shows the pressure variation at the evaporating pans without the accumulator; the middle line the steadying of that pressure when the accumulator is in use and the lower curve, the manner in which the accumulator pressure varied in storing and delivering steam.

Cooperation Between Private Plants *and the* Utilities Part III

By
O. H. HENSCHEL Consulting Engineer Milwaukee, Wis.

IN PREVIOUS ARTICLES, we considered several different schemes for reducing the power and steam costs in a factory devoted to the manufacture of wooden toys. In this analysis, it was shown that the most favorable arrangement was that in which a 125-kw. turbine set was installed and in which all power in excess of that capable of being generated by this unit was purchased.

Now we will consider another plant, this time, a furniture factory having a connected power load of 440 hp., and a connected lighting load of 58.6 kw., a total of about 387 kw. Here again, the economy of the system was improved by a partial generation scheme.

Electric energy requirements and costs at this plant covering the 28-mo. period for 1929 and 1930 were examined and found to average 16,980 kw-hr. per mo. at $394.80 per mo., or 2.3 cents per kw-hr.

Steam originally was used only for heating and process and was supplied by either one or both of one 100 hp. and one 80-hp. horizontal return tubular boilers. The appraised values of the boiler room equipment was

Boiler room building	$ 5,188.46
Steel stack and foundations	1,895.98
Boilers and fittings	7,476.88
Lighting system	95.67
Sprinkler system	307.50
Dust collector	569.05
Pumps and piping	Not given
Tools and miscellaneous equipment	584.97
Total	$16,118.51

The average annual operating charges for this plant were

Coal	$4,929.29
Equivalent value of wood waste	925.00
Boiler room expense such as fireman's wages, repairs, supplies, insurance (such as fire, boiler, compensation), etc.	2,500.00
Total	$8,354.29

Rather than to accept a flat rate of depreciation each one of the major items comprising the steam generating plant were taken separately. The resulting actual value of depreciation, then, was as

ITEM—	Value given	per cent Depreciation	Actual Depreciation
Boiler room building	$5,188.46	2	$103.76
Steel stack and foundation	1,895.98	10	189.59
Boilers and fittings	7,476.88	6.67	495.85
Lighting system	95.67	3	2.85
Dust collectors	569.05	10	56.90
Sprinklers	307.50	5	15.35
Tools and miscellaneous equipment	584.97	20	116.99
Total apparent depreciation			$981.29

From this it was obviously then possible to enumerate the steam generation plant annual fixed charges as

Interest at 6 per cent	$ 967.08
Depreciation as above	981.29
Taxes and insurance at 4 per cent	644.72
Total	$2,593.09

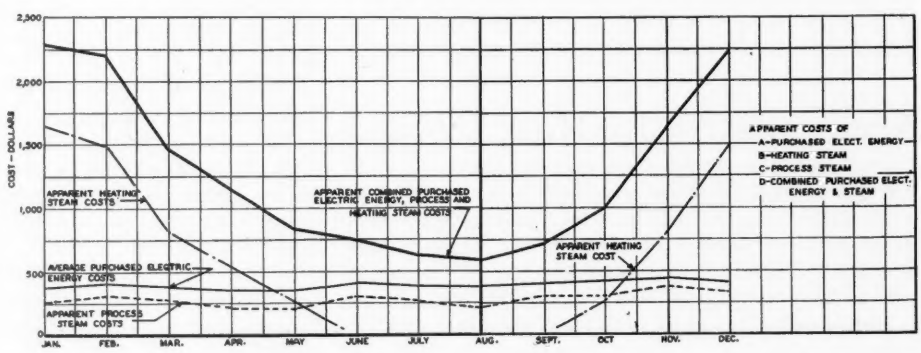
with resulting combined operating and fixed charges appearing below.

Operating charges	$ 8,354.29
Fixed charges	2,593.09
Total per annum	$10,947.38

Estimated Steam Costs

Having no other course to follow, because of conditions existing, a total of $5,854.29 was assumed to cover the total fuel cost whether wood waste and other refuse was burned or not, so that with an annual purchase of 1,855,430 lb. of coal at a cost of $1,929.29, it would appear as if the equivalent coal consumption was equal to 2,251,650 lb. per yr.

Accordingly, then, with average evaporation of 6.5 lb. of water per lb. of fuel burned the annual generation appeared to be equal to 14,635,725 lb. of steam. As already indicated, combined fixed and operating charges were equal to $10,947.38 so that as a consequence with



VARIOUS EXISTING COSTS OVER A PERIOD OF ONE YEAR. CURVES SHOWING THE EXISTING COSTS, BOTH COLLECTIVELY AND INDIVIDUALLY, OVER A PERIOD OF ONE YEAR, JANUARY TO DECEMBER.

an annual generation of 14,635,725 lb. of steam the unit cost was $0.74 per thousand pounds. Investigation disclosed an approximate consumption of 9,886,320 lb. of steam per annum for heating.

Accordingly, then, by process of elimination we have

Total annual steam generation	14,635,725 lb.
Space heating requirements	9,886,320 "
Process steam requirements	4,749,405 lb.

Because of the fact that electric energy consumption month by month might to a great degree be accepted as an indicator of production activity, it appeared justified to employ a variation in steam process consumption in phase with monthly electric energy consumption variation. From a study of the monthly energy consumption, therefore, the apparent yearly consumption process steam was calculated to be 4,619,607 lb.

With the data and information then at hand, it was possible to determine and present the various existing costs involved, both collectively and individually. These are being presented in the following order:

(1) Average apparent monthly purchased electric energy costs based upon 28-month period considered.
(2) Apparent monthly cost of steam used for space heating.
(3) Apparently monthly cost of steam used for process, etc.
(4) Combined costs.

They are illustrated graphically in Fig. 1.

Average apparent monthly purchased electric energy and consumption and costs for the 28-month period under consideration were:

Average total for 28-month period under consideration	204,900 kw-hr.	$4,764.09
Monthly average for 28-month period under consideration	17,075 kw-hr.	396.74

On the basis of the unit cost of $0.74 per thousand pounds of steam, the annual space heating consumption and costs were 9,886,200 lb. costing a total of $7,315.77. Since the process steam requirements were 4,619,607 lb. the total space heating and process steam requirements were 14,505,927 lb. and this at $0.74 per thousand lb. costs $10,734.25.

We may now summarize:

Average annual purchased electric energy costs covering 28-month period under consideration	$ 4764.09
Apparent annual cost for space heating	7315.77
Apparent annual cost for process	3418.48
Total	$15,498.34

thus indicating an apparent combined purchased electric energy and steam costs equal to $15,498.34 per year.

Full Generation and its Costs

Originally, previous to investigation, it was deemed probably feasible and financial advantageous to generate all of the electric energy requirements. This phase of the subject was then investigated. From preceding data, there appeared

An average monthly maximum consumption of ..... 21,800 kw-hr.
And an average monthly minimum consumption of ..... 13,700 kw-hr.
so that as a consequence, based on a 26-work day month and an eight-hour day, one could well expect to have
An average hourly maximum consumption of .. 105.0 kw.
And an average hourly minimum consumption of ..... 65.8 kw.

These values are, of course, not indicative of the required capacity of source of supply. In order to arrive at a conservative value for this factor, consideration must be given to (a) the connected load and (b) a load factor applicable to the kind of industry, namely wood working. In this common practice appears to favor a load factor of approximately 0.24 so that the most logical required generating unit rating would be that of (0.24 × 386.93) 92.86 kv-a.

In view, however, of the fact that a machine of this size would not be applicable and in order to provide for some future additional load, it was recommended that consideration be given to a unit of 125-kv-a. rating.

Editor's Note: This is the third of a series of articles on this subject by Mr. Henschel. A fourth, discussing further aspects of this problem will appear in a subsequent issue.

Electric Eyes to Protect Passengers

Sure and swift "electric eyes" will safeguard passengers entering or leaving the high-speed elevators furnished by the Westinghouse Electric Elevator Company in Rockefeller Center in New York City.

An automatic device, recently perfected, and known as the "Safe-T-Ray," will protect anyone moving through the elevator entrance from the hazard of being struck by the fast moving power-operated doors. Light beams are to be projected across the elevator entrance and focused on photo-electric cells in such a way that the passenger will interrupt the beams in passing through the doors.

If a passenger, or any other opaque object, gets in the path of the beams, so that a shadow is cast on the photo-electric cells, the doors will remain open or, if closing, will stop immediately and automatically reopen.

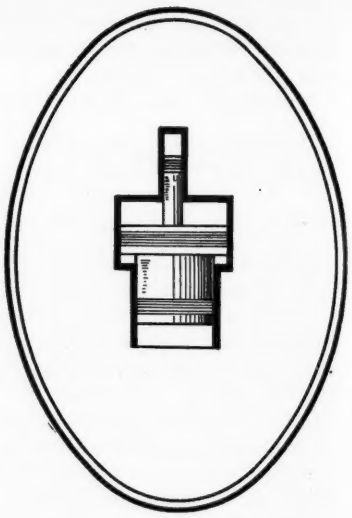
This development also accelerates the operation of the elevator by making it possible to open and close the doors at greatly increased speed, yet with perfect safety.

Steel boiler orders placed in February, 1932 reached a total of 204 boilers of 244,927 sq. ft. heating surface, according to reports of 72 manufacturers submitted to the Bureau of the Census. This total was distributed as follows: 25 water tube, 147,416 sq. ft.; 12 horizontal return tubular, 14,392 sq. ft.; 33 vertical fire tube, 7238 sq. ft.; 9 locomotive not railway, 10,031 sq. ft.; 109 steel heating units, 49,277 sq. ft.; 1 oil country, 752 sq. ft.; 11 self-contained portable 6443 sq. ft.; 1 miscellaneous, 5000 sq. ft.; 3 marine, 4378 sq. ft.

In a transformer the wave form of the primary current depends upon the secondary current and the nature of the load.

POWER PLANT ENGINEERING April 15 1932

DIESEL ENGINE UPKEEP



PART XXI. LUBRICATION OF AIR COMPRESSOR CYLINDERS ON DIESEL ENGINES. CARBON ACCUMULATION. LUBRICANT FEED REQUIREMENTS. PREVENTION OF CORROSION. CLEANING AIR PIPES

BY EDWARD J. KUNZE

AIR COMPRESSOR cylinders on Diesel engines are rarely under-lubricated but often over-lubricated. Usually sufficient heat is created during compression to char the lubricating oil unless it lies in a thin film on the cylinder walls which keep it cool. Free oil flows onto the discharge valves where it is burned due to the intense heat, forming carbon deposit. Carbon formation occurs also in the discharge pipes, which are also hot, restricting the air passage and increasing the pressure on the compressor. The oil may pass into and form pockets in the cooling coils.

Oil vapor coming from carbon deposits, if ignited, may explode if there is enough of it. Such explosions rarely occur and may be prevented. Burning of the carbon in the cylinder is not necessarily dangerous but if it lifts the relief valves it may anneal the springs. If the explosion is severe it may melt the brass relief valves. If burning is noticed, it may be stopped by shutting down the engine or by closing the air valve. If the air is throttled down and the drains opened, the carbon may be allowed to burn out if no parts become excessively hot. It is essential, therefore, that the air temperature be observed. Normally the temperature of the air leaving the after-cooler should be about 120 deg. F.

CARBON ACCUMULATION

Accumulation of carbon may cause improper cooling of the air as it passes through the compressor, intercoolers or aftercooler or may over-heat some of the piping. Accumulation of carbon residue deposits in the intercoolers or aftercooler or in the valve passages or pipe connections may restrict openings through which the compressed air must flow, hence back pressure will be built up to such an extent as to make explosion possible.

Excessive lubrication is caused, sometimes, by oil working up from the crankcase. Contrast in carbon accumulation on air compressor valves run for approximately the same time under similar conditions of service is shown in Fig. 1.

The oil used on A was of unsuitable grade and applied too freely while that on B was of proper grade and fed sparingly. Excessive lubrication also gums up the valves.

Deposits of carbon are caused partially by decomposition of the oil. Mineral lubricating oils, regardless of their base, will decompose to volatile products and carbon residue when subjected to air which is sufficiently heated and under sufficient pressure. For this reason, an oil having a wide range of distillation, high end point or too great a viscosity is objectionable because, instead of vaporizing cleanly, it breaks down and becomes sticky and collects dirt. The slower the breaking down process or the greater the volume of oil used, the greater will be the ultimate amount of carbon residue.

Scale, baked hard from carbon and dust mixture, may be built up on the piston and cylinder head until these two will just touch with normal piston travel but will knock if this travel is increased. Such a knock may occur also through change in temperature of the compressor. Another cause is a change in load on the compressor, particularly when the air is throttled to such an extent that the compression is insufficient to cushion the piston. Combustion knocks are easily identified from bearing knocks by their cessation when the fuel is shut off.

Automatic forced feed lubrication, whereby the flow of oil to each part of the cylinder can be regulated, is perhaps the most efficient and economical method of lubrication for air compressors. By this means, possibility of overfeeding oil by any particular lubricator is reduced, for oil flow stops and starts with the compressor and the requisite lubricating and sealing film is attained. Forced feed lubricators are not affected by variations in air pressure and they will feed the oil continuously in accordance with their adjustments and the speed of the compressor.

LUBRICANT FEED REQUIREMENTS

Proper quantity of lubricant feed cannot be stated generally. It is essential to guard against over feeding. It is a safe rule to use just enough oil to prevent frictional wear and to permit easy and free operation of all parts; more than this will lead to trouble. The discharge valves should, therefore, be examined regularly and the aftercooler, receiver and discharge pipes blown out. This will remove effectively any oil, water or sediment which may have accumulated. If the discharge valves, upon removal, appear greasy, enough oil has been fed to the

cylinders; on the other hand, if the parts appear extremely oily and little pools of oil are found in the compressor pockets or in any of the air lines, oil is being fed in excess of that required.

A general rule is that air compressors are lubricated sufficiently if one or two drops of proper grade oil are used for each 500 to 600 sq. ft. of cylinder surface

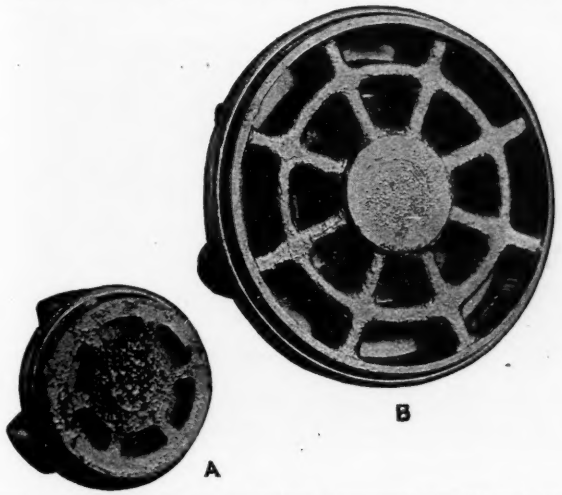


FIG. 1. CONTRAST OF CARBON ACCUMULATION ON AIR COMPRESSOR VALVES OPERATING UNDER POOR AND PROPER CONDITIONS

swept by the piston per minute. This rule, however, must be modified according to the condition of the cylinders and the temperature and degree of compression.

Moreover, the number of drops of oil which can be secured from a certain amount of any grade of oil varies with the viscosity, temperature, service conditions involved and the diameter and shape of the lubricator orifice. The type and design of lubricator will also affect the number of drops obtained. Varying temperatures of the room will affect the feed of the lubricator and with different types of lubricators the difference in the size of the drops is quite appreciable. Inspection of the wearing surface is, therefore, a better guide for determination of the proper quantity of feed under the prevailing conditions than any other guide.

Deposit of water condensed from the air in the compressor will vary, in amount, with the humidity of the atmospheric air. In tropical climates it may be so great as to require keeping the intercooler drains cracked all the time. Such drainage will also remove the sludge formed by excessive lubricating oil. If this oil is not drained, it tends to form a scale on the tubes of the cooler that interferes with the cooling process. Drains should be left open while the compressor is not operating. Coolers must be watched for signs of leaks. It is not uncommon for pin holes to develop in the tubes and permit air to blow into the cooling water. If the water spaces in the coolers are in series with the engine cooling water system, this air leakage may develop air locks which will interfere with proper cooling of the power cylinders. If excessive air collects in the cylinder head jackets, as indicated at the vent cocks on the outlets, the compressor coolers should be inspected for leaks.

Corrosion of compressor parts is caused sometimes by use for lubrication of an animal or vegetable oil mixture which may form an acid compound. If acid corrosion is suspected, it may be tested for easily by draining the coolers into a clean bottle or test tube and immersing a piece of polished brass or copper in this drained liquid. If the metal is not tarnished in 24 hr. after standing in a warm place, there need be little fear from acid. A straight mineral oil should not form acid.

Coolers should be cleaned regularly. If the sediment comes out with difficulty, a lye solution may be forced through the cooler. This should be followed by a 10 to 1 solution of hydrochloric acid, which should be forced through the cooler until all effervescence ceases. The cooler should then be washed out thoroughly, first with cold water and then with hot water to remove all traces of acid and any dissolved or partly disintegrated scale. Since the pressures cannot be gaged directly at the cylinders because of the pulsation which is set up, they are generally gaged at the drain connectors on the traps, therefore it is possible for the cylinder to be laboring heavily as a result of carbonized discharge pipes without showing it on the pressure gages.

Cleaning Air Pipes

Carbon deposit may be found in the discharge air pipes. The easiest way to remove this carbon is to heat the pipe in a charcoal fire to a dark red color, then allow it to cool. The deposit may then be loosened and removed by jarring the pipe with a soft hammer. The pipe should then be blown out with air before putting it back into service.

Because of the danger of leaving some lye or acid in the apparatus, some engineers prefer to use a strong solution of ordinary brown soap and water. This is introduced at the intake valves into the cylinder or forced into the indicator connections of the air cylinder with a hand pump while the compressor is running. If the cleaning is to extend no farther than the receiver, close the discharge valve of the receiver and discharge the dirt and suds through the receiver drip cock. The air line may be cleaned in a similar way, by closing the receiver drip and opening the receiver discharge valve after compressor and receiver have been cleaned.

Soap solution must be cleaned from the parts or the accumulation of soap may carbonize and burn. Trade cleansing materials for this purpose are in the market.

Since scavenging air compressors operate at such low pressure as 2 to 10 lb., their operation is much simpler.

Flat disc and flat strip valves are applicable to this type of compressor. A multi-strip valve for this purpose is illustrated in Fig. 2. This consists of strips of steel ribbon that rest upon the valve seat and cover the slots in the grid. They are held in place by a retainer plate, the bridge of which covers the valve strips but touches it only at the ends, permitting these strips to bow up in the middle when pressure is exerted. Operating troubles with scavenging air compressors are rare.

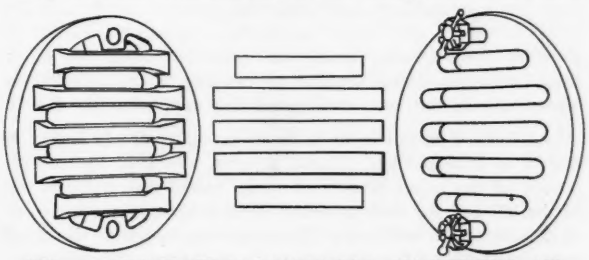


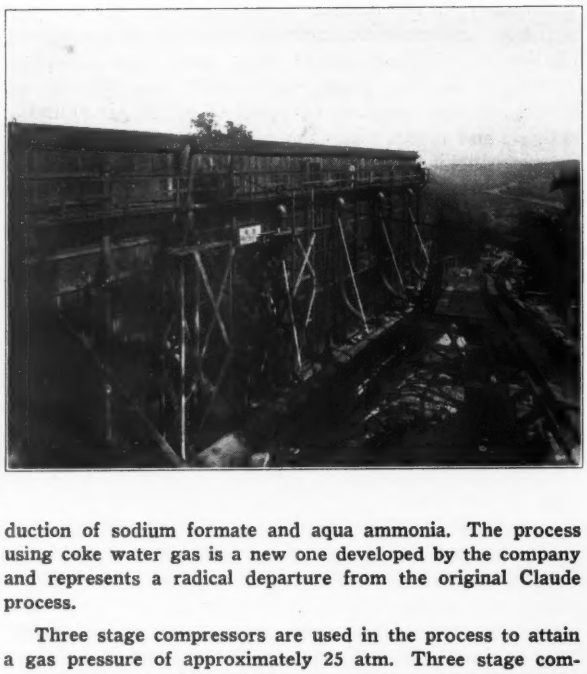
FIG. 2. MULTI-STRIP VALVE FOR SCAVENGING AIR COMPRESSOR

POWER PLANT ENGINEERING April 15 1932

Unusual Power Recovery System

Water Used at 25 atm. Pressure in Process Work Aerated and Used Over with a Recovery of about 60 per cent of the Power

IN THE KANAWHA VALLEY at Belle, W. Va., the Ammonia Department of the E. I. du Pont de Nemours & Co.., has a large plant for the manufacture of anhydrous ammonia, menthol and the logical subsidiary operations, production of sodium formate and aqua ammonia. The process using coke water gas is a new one developed by the company and represents a radical departure from the original Claude process.



Three stage compressors are used in the process to attain a gas pressure of approximately 25 atm. Three stage compressors then to give a final pressure of approximately 1000 atm., the intermediate stage pressures being about 85 and 325 atm. At the 25 atm. stage the gas is scrubbed by water. In previous installations, power was recovered from the water used in the scrubbing process by running it through Pelton water wheels, the head available being approximately 850 ft.

At Belle, a mountain or hill with an approximate height of 800 ft. is available and a novel scheme was used for the recovery of the waste power. A spray tower was built on top of the hill and the charged water from the scrubbers is forced to the top of the hill by the 25 atm. pressure and the dissolved gases released to the atmosphere in the tower. The regenerted water from the base of the tower is then returned to the suction of the pumps which boost the pressure sufficiently to deliver it to the scrubbers. Water reaches the pumps at a pressure of about 400 lb. and about 60 per cent of the power used in the scrubbers is recovered at a lower investment than for Pelton wheels.

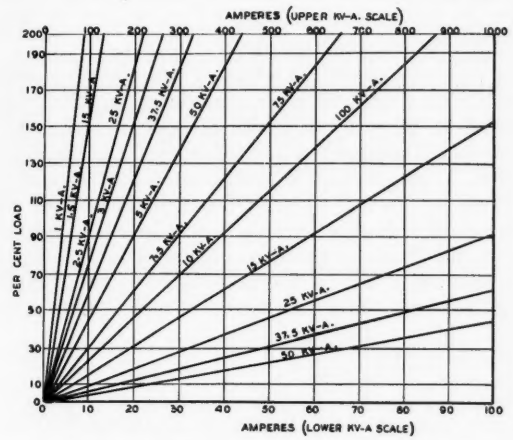
Two piping systems are used, one for each snythesis building, each system consisting of a supply and return line made of 36 in. pipe, 3000 ft. long. The pipe is hammer welded with bump type riveted joints. Wall thickness ranges from 3/8 in. at the top to 7/8 in. at the bottom. The slope of the mountain is approximately 45 deg. and special anchors, visible in the photograph were necessary.

The plant itself is located near the river just behind the trees at the left of the center picture which shows the aeration tower from the side to which the gas laden water is delivered. The top picture shows the four lines up the mountain side and the bottom picture three of the booster pumps. Two of these pumps are motor driven and one turbine driven so as to permit balancing of winter and summer loads on the electric system.

Readers' Conference

Curve for Finding Load on Transformers

WHEN RECORDING DISTRIBUTION transformer load records, it has been found that a curve is very useful to read the per cent loading when the amp. are known.



CURVES SHOWING PER CENT LOAD OF 230-V. WINDING OF DISTRIBUTION TRANSFORMERS WHEN CURRENT IS KNOWN

For 115-v. winding divide amp. by 2 before using curve.
For 460-v. winding multiply amp. by 2 before using curve.
For 2300-v. winding multiply amp. by 10 before using curve.

The curve presented is plotted for use when recording the per cent loading of standard distribution transformers in sizes from 1 to 100 kv-a. with 115—230-volt secondary windings connected for single phase 3-wire service.

Ammeter readings are taken from each of the 230-v. transformer leads and averaged. Any serious unbalance should of course be corrected. If the transformer is connected to two wires, only one reading will be needed.

Wherever one of the diagonal lines is used for two sizes of transformers, the ampere scale on the left should be used for the smaller transformer and the ampere scale on the right for the larger transformer.

The following example will serve to show the use of these curves:

Example 1

5 kv-a. transformer, 26 amp. Follow the 26-amp. vertical line from the bottom to where it intersects the diagonal line used for 5 kv-a. and 50 kv-a. transformers. Then read 120 per cent from the percentage scale.

Example 2.

50 kv-a. transformer, 240 amp. Follow the 240-amp. vertical line from the top to the same diagonal line as in example one and read 110 per cent from the percentage scale at the left.

Example 3

50 kv-a. transformer, 78 amp. Follow the 78-amp vertical line from the bottom and use the 50 kv-a. diagonal line provided for 50 kv-a. transformers having loads under 100 amp. Read 35 per cent.

The curves can also be used for 115 v., 460 v. and 2300 v. transformer windings when following instructions printed below the curve.

Iron Mountain, Mich. L. W. WYSS.

Safeguards for Transmission Equipment

MANY SPUR gear power transmissions are left unguarded and accidents due to this omission have been common in the experience of the writer. For example: In reaching upward to throttle a steam valve overhead, our chief engineer was caught in an unguarded spur gear drive. This stopped the main and countershafts when the driver pulley from the engine pulley fortunately slipped, allowing the victim to escape with his life but with a badly mangled arm.

Another recent incident happened in a plant situated at the Alaska boundary. An exceptionally large run of

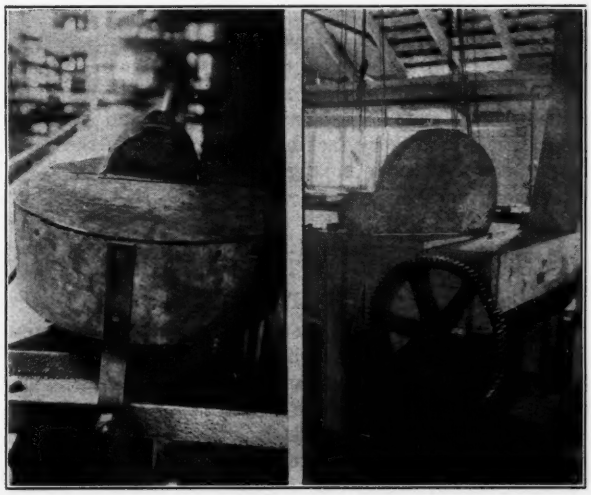


FIG. 1. SHEET METAL GEAR CASE COVERS SPUR DRIVE IN NARROW PASSAGEWAY
FIG. 2. GALVANIZED IRON GUARD MADE TO COVER GANG SPROCKETS WHERE GIRL WAS CAUGHT

salmon found the girls at their machines working long shifts that tend to increase accidents, especially where mechanical movement is not guardedly "fool-proof." While a set of gang sprocket chain drives were three-quarter guarded, a breeze whisked a few loose strings of frayed dress fabric from the dress of the machine tender underneath the guard. Her agonizing shriek was almost drowned by the din of roaring machines and steam exhaust. The second call came to the writer as some noise foreign to operating sound. Dashing across the factory we found her body being slowly drawn, doubled almost in two by the revolving gang sprockets.

Luckily she fainted and in doing so fell on the clutch bar, throwing it almost clear but allowing a "stuttering" movement of the transmission. At that, no time could be lost. A sharp knife cut her clear, bruised and

shaken, otherwise unharmed. As a test, we flicked a rag toward the shaft and on the tenth test it engaged itself and commenced slowly to wind. In this instance, if the shaft had been turning up at a high speed then a matter of seconds would have added another victim to the list of fatalities charged to unguarded shaft and gear transmission. Fool-proof guards are the only 100 per cent assurance of Safety First.

Many factory inspectors have their eyes open for unguarded shaft ends and old style shaft collars with protruding set-screws and rim flanges, that catch clothing with unfortunate results. A desire to turn over a new plant in a hurry found the writer making use of this type while waiting for a requisition to be filled for the safety collars after warning the operator not to go up overhead. In a matter of moments one foolhardy individual did so and was soon clinging to a building brace to save his hide as his trouser leg caught a protruding set screw. I loaned him an overcoat with which to cover his complete nakedness while proceeding homeward, a sadder but a wiser man.

It goes against the wishes of many executives to scrap the old style shafting hangers in which the bearing box is just suspended by the tension of two side set-screws. One line shaft fell down on the writer's machines and smashed them when set-screws worked loose by the overhead vibration, in spite of the fact that the inspector had ordered V-irons to pass under boxes of the hangers and up through the hanger cross-tree framing overhead. At the same time he had ordered shaft ends to be guarded. This may be easily and cheaply done in many cases by tacking an old tin over the end. In any case, a wooden boxing is cheap.

Vancouver, B. C. S. H. Cooke.

Steam Engine Drive for Auxiliary Apparatus

In many instances where factories and other enclosed spaces are heated by blasts of air forced through nests of steam coils, the advantage of using a convenient type of vertical steam engine to drive the blowing apparatus appears to be overlooked. Steam generated at a high pressure is delivered to the heating coils through reducing valves which cut the pressure down to about 4 or 5 lb., while electric motors, which contribute no energy at all directly to the heating process, drive the fans. Evidently, the more economical way would be to discard the reducing valves and substitute steam engines for the motors, for in that case the engine would function as a reducing valve in the principal operation of delivering heat while the power it would expend in circulating the air would be a byproduct, costing little except the overhead on the difference in investment.

Consider, for example, a centrifugal blower running 130 r.p.m. and delivering about 98,000 cu. ft. of air a minute against a static pressure of 1 in. of water. To drive this blower at its rated capacity would require about 35 hp. Suppose an induction motor having an efficiency of 88 per cent and a power factor of 90 per cent were chosen for the work and that electric current cost two cents a kilowatt-hour. The power cost for a heating season of 200 days, running 24 hr. a day, would then be approximately

$$(35\times0.746\times200\times24\times2)\div(0.88\times0.9\times100)=\$3165$$

This is, practically, the expense that would be saved if a 35-hp. steam engine, exhausting into the heating coils against a back pressure of from 3 to 10 lb. or more, as circumstances might require, were substituted for the electric motor.

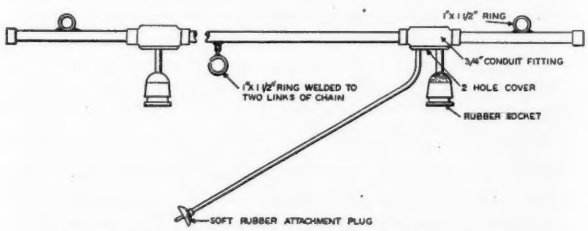
In any situation where exhaust steam can be utilized profitably, as in manufacturing processes, considerations of economy suggest that the dependable and substantially built vertical steam engines now offered ought to have the call for such services as driving stoker feed-shafts, forced-draft fans, ventilating blowers, cupola blowers, and similar accessories. But where the exhaust from such engines would have to be wasted to the atmosphere, the most economical drive for a blower or draft-fan doubtless would be the electric motor.

In this connection the effect of fan speed on power consumption should be given consideration. The power required to drive a fan varies directly as the cube of the speed. Therefore, a fan of ample size should be selected, so that it may be driven at a moderate speed, say from 150 to 200 r.p.m. Of course the cost of such a fan would be higher than for a smaller high-speed fan that would displace the same quantity of air in the same interval of time. But the small initial increase of expenditure would be offset by the superior operating economy of the moderate-speed fan.

St. Louis, Mo. D. J. Altizer.

Portable Lighting Fixtures for Furnace Work

A safe and dependable portable lighting fixture, for use under boilers, that distributes plenty of light to all parts of the furnace below the tubes, was made at small cost at a large steam plant, equipped with 500-hp. B. & W. boilers. Besides supplying plenty of light, it was found that the breakage of the 100-watt lamps was reduced considerably. Also, the work of replacing stoker parts, and repairs to brickwork, was speeded up.



DETAILS OF PORTABLE LIGHTING FIXTURE

The fixture was made of ¾-in. conduit and steel conduit fitting, and was wired with 3-wire rubber covered super-service cord. The third wire is for the purpose of grounding the fixture to the conduit system, at the outlet supply current to the unit. If desirable, this ground wire may be dispensed with and a two-wire cord may be used.

From the sketch, it will be noticed that the supporting rings are welded to an extension piece that is capped on the end with ¾-in. pipe caps. These extension pieces are provided to keep the lamps from swinging against the brickwork, when the fixture is moved along the tubes.

All metal parts should be tack welded after they are screwed together and before the fixture is wired. The

hanger hooks are of 5/16-in. cold rolled round stock and are long enough so that the tips of the lamps are 6½ ft. above the grate. The 2-prong or 3-prong polarizing attachment plug is of the soft rubber type. The open ring in the center and on the under side of the fixture is used to support the extension cords. This keeps the cords up out of the way.

Many places will be found around the plant where this fixture may be used.

Springfield, Mass. ALVAH S. JAMIESON.

Why the Geyser Action in the Steam?

BOILER OPERATORS in the power plant are often troubled with water in steam. Slugs of water are carried along with the steam, especially after a steam valve has been suddenly opened. My explanation of this "geyser action" is as follows:

Referring to the accompanying sketches, in Fig. 1 the steam valve is closed. The pressure in the boiler is,

FIG. 1. CONDITION OF BOILER WATER UNDER STEAM PRESSURE AND NO LOAD
FIG. 2. SUDDENLY OPENED STEAM VALVE RAISES WATER LEVEL AND PRODUCES GEYSER UNDER STEAM OUTLET

say, 200 lb. There is a fire beneath the boiler and steam is being generated. That being the case, it is logical that throughout the entire body of water in the boiler we have small steam bubbles somewhat as pictured in my sketch, Fig. 1. The size of these bubbles is dependent upon the pressure in the boiler.

Figure 2 represents the same boiler with the steam valve suddenly opened. As soon as any valve is opened there always is a reduction of pressure within the boiler; therefore, in Fig. 2 the pressure is less than 200 lb. Probably it is 195 lb. or even 199 lb. Whatever it is, it is bound to be less than 200 lb.

That being the case, the bubbles in Fig. 2 are certain to be larger than the bubbles in Fig. 1. The enlarged bubbles naturally increase the volume of water in the boiler; that is, they raise the water level. This is a well known fact which has been proven many times.

At the same time, with reduction in pressure the water in Fig. 2 boils more violently. There is a rush of steam out through the opening. All of these factors contribute toward "sucking" the water out which creates the "geyser effect". The only reason why the geyser action occurs directly beneath the opening is that the flow of steam must be through the valve itself, consequently that's where the geyser action is. The great velocity of steam in the neighborhood of the valve pulls the boiling water along with it in the form of slugs.

There are four ways in which to avoid slugs in steam—(1) by maintaining a low water level: (2) by using an outlet pipe so large that the exit velocity will not cause geyser action; (3) by installing a separator which will remove the water from the steam; and (4) by passing the steam through a superheater.

Newark, N. J. W. F. SCHAPHORST.

Heat for Swimming Pool

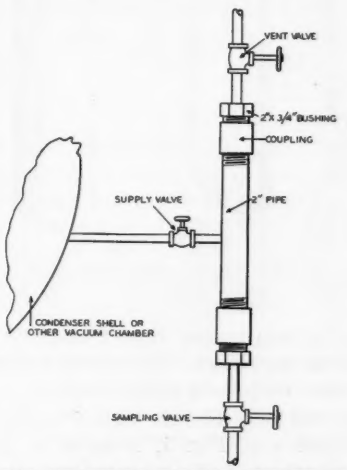
HEATING SWIMMING pools by electricity as described on page 252 of the March 15 issue has the disadvantage of increasing the length of periods between tank cleanings although with proper filtration and sterilization, frequent tank cleanings are not necessary.

Wheaton, Illinois, has adopted what might be called a manual method of heating fresh water supplied for its municipal swimming pool although the term "manual" anticipates much. Here all of the water is renewed each Wednesday night. The next morning the tank is open to the children of the community without charge and this brings certain fond mammas with their children who also aid in the heating process while paying for the privilege. This method of heating costs only a small loss in revenue from children's tickets but it offers pleasure to many children to whom the usual charge for admission would be a bar. Paying philanthropy such as indicated above has been practiced successfully in connection with other municipal projects but nowhere has it caused those who serve it to so graciously lick its hand for the privilege.

Wheaton, Ill. EDWARD J. KUNZE.

Sampling Pot for Vacuum

EASILY constructed is a pot for drawing a sample of liquid from a container in which a vacuum exists as shown in the accompanying drawing. A 2-in. pipe is



DEVICE FOR DRAWING SAMPLE UNDER VACUUM

mounted in a vertical position and is of length to give a volume sufficient to supply the required sample. Two-inch couplings, reducing bushings to ¾-in. nipples and globe valves are connected as shown in the drawing.

Starting with all valves closed and a high vacuum in the container, to secure a sample proceed as follows; the supply valve is opened for several minutes and then closed. The vent is opened and a sample of the liquid may be drawn from the sampling valve when opened.

This method may be used on a number of different pieces of equipment such as condensers, condenser tail water pipes, feedwater heaters, evaporators, and the like.

Boston, Mass. HARRY M. SPRING.

FOR A HEATING SYSTEM, pipe runs left exposed in rooms to be heated are effective as radiation and the cost of insulation is saved.

Means for Sampling Oil Shipments

WE USE CONSIDERABLE oil around in different places and from time to time we have occasion to make tests on it, that is, our chemist makes the tests on the samples that are taken out through the plant and reports the results back to us and to the purchasing department, so we can check up on them and compare them with specifications with which they are supposed to agree. This has never been altogether successful and sometimes causes trouble which was usually pinned on the chemist. He said it was the sampling and so in order to get the thing right we got together and fixed up some sampling tools or devices called thiefs and now sampling is done

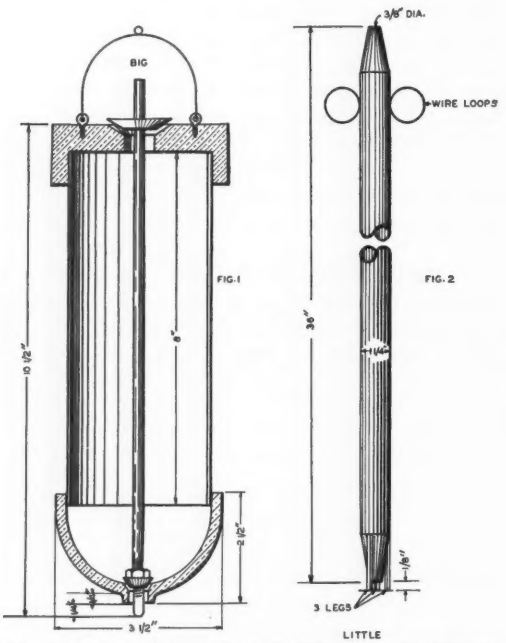


FIG. 1. OIL SAMPLER FOR TANK CAR SHIPMENTS
FIG. 2. SAMPLER USED IN OIL DRUMS

according to instructions agreed upon by the oil company and the purchaser. The sketches of the thiefs are in accordance with their suggestions.

We use the long thin one shown in Fig. 2 for drums and the other one, Fig. 1, is made so that it can be used on tank cars. We do not have many cars but thought it best to have everything as nearly right as possible in case we needed it later. Oil men tell us that under no condition should samples be taken from the unloading valve on the car. If this is done the water and sediment may be too high because it settles to the bottom and of course does not look good for the oil company and of course does not give a good sample which after all is what we make the tests for.

Figure 1 does not require any explanation as any machinist will understand how to make it from the sketch. The thin one, Fig. 2, is made from sheet metal with two cone shaped ends soldered on. The whole thing should be about 3 ft. long and the small ends of the cone should be about ⅜ in. in diameter so that it can be covered up completely with the thumb. The rings to hold it with are soldered on and the three legs should be long enough to hold it about ⅛ in. off the bottom of the drum.

As it was our desire to get a sample from close to the bottom of the tank, we use the sampler in the following manner: With the sampler held vertically and the thumb over the top hole, thrust the device slowly down into the oil until the legs touch the bottom, then remove the thumb until the level of the oil in the sampler is the same as that in the tank. To transfer this sample to a bottle, the thumb is again placed over the top hole and the sampler withdrawn. Removing the thumb will permit the oil to run out at the bottom hole which should be held over the bottle.

To get a fair average sample the device is used as described except that the thumb is placed over the top hole only while the sampler is being removed from the oil.

When the sampler is soldered it is best to use a rosin solder flux so that it can all be washed off later with gasoline. Sometimes the flux from a new sampler causes noticeable errors. This is also true of cans used for samples.

We make it a practice to let all drums lie on their side with the bung up overnight before taking the sample. The thief is washed in gasoline every time it is used and then stood up vertically in a little cabinet we built right over one of the steam lines so that it is always dry and warm.

The samples are put in bottles which the chemist prepared and which he keeps in cardboard boxes while they are coming over from the laboratory and going back. The cork is a new one wrapped in tin foil. He washes each of them in gasoline and then soap suds and dries them. He says that bottles are better than cans because you can see whether they are clean. Light, however, causes changes for some tests so the cardboard cover is used. We try not to touch the thief where it goes into the oil. First it is lowered in the oil about a foot and rinsed out and then put clear to the bottom for the sample. This procedure is good even for taking samples for dielectric tests on transformer oils and is much more careful than the average sample needs but we thought that we might as well learn to do it right in all cases.

Brooklyn, N. Y. P. F. ROGERS.

Reading Gages at High Altitudes

WHERE a refrigerating plant is used at altitudes much above sea level, the indications of the pressure gages will be affected. The internal working of the plant will not be affected, owing to its being a closed cycle and entirely shut off from the atmosphere. Actual temperatures and pressures within the plant will remain unaltered, but as the pressure gages measure the difference between the pressure inside the gage tube and that outside, their reading will obviously be affected. At elevations not above 1000 ft., the error can be neglected but at 8000 ft. above sea level, a pressure gage would read about 9 lb. high. At high altitudes, the gage pressure would indicate a higher pressure than really exists and this must be taken into consideration when working where the barometer is low.

Herts, England. W. E. WARNER.

IN ILLUMINATION design, a lumen may be defined as being equivalent to the quantity of light intercepted by a surface of 1 sq. ft., every point of which is at a distance of 1 ft. from a source of 1 candle.

Plant Operation Problems

Pump Troubles?—Let's Have Them

WITH THE advent and growth of the use of high-pressure and high-temperature boiler feedwater have come operating difficulties with boiler feed pumps which were not experienced with lower pressures and temperatures. A compilation and classification of these difficulties seems desirable and readers of Power Plant Engineering are requested to send in an enumeration of the troubles they have experienced and the remedies they have found effective. When sufficient information has been collected the data will be tabulated for the benefit of readers.

Motor Operation Problems

AMONG THE VARIOUS questions regarding motor operations which appeared on page 183 of the February 15 issue, several were of interest to me. With regard to this second question, the efficiency loss in reconnecting a 2-phase motor to operate 3 phase varies somewhat with the type of connection used in effecting the change.

The resulting loss in horsepower, however, will be about 13 per cent, even though the reconnected winding is equal in efficiency to the original winding. This loss is due to the difference in power output of 2-phase and 3-phase circuits. Given equal voltage, amperage, and power factor the resulting watts will be 13.4 per cent less in the 3-phase circuit than the 2-phase.

Also, an average 2-phase motor has approximately 25 per cent more turns of correspondingly smaller wire than a 3-phase motor of like characteristics; consequently, to reconnect this 2-phase motor to operate 3-phase, it will be necessary to cut out about 20 per cent of the existing turns. With these turns cut out and the remainder reconnected properly, the motor will then operate on a 3-phase circuit of the same voltage at the same current rating as when connected for 2-phase operation assuming that the efficiency of the reconnected winding is equal to the original 2-phase winding the power loss can be easily seen in the following formulas:

$$\frac{\text{Power in 3-phase circuit}}{\text{Power in 2-phase circuit}} = \frac{I \times E \times P.F. \times 1.732}{I \times E \times P.F. \times 2} = .866$$

in which equal voltage, amperage, power factor and efficiency can develop in a 3-phase motor only about 87 per cent of the horsepower of a similar 2-phase motor.

In the question giving the resistances of the different phases of the motor, in which phase the trouble exists will depend on how the motor is connected, Star or Delta.

If the winding is delta connected the trouble will be found in phase one and more than likely will be a shorted coil. In a star connected winding, however, the fault will be in phase three and in all probability is a poor or corroded connection.

In the fifth question, the loading of a 5-hp. motor with an average load of 110 per cent and a 1½ to 2 hours load of 136 per cent is more than a motor should be loaded, if good service is expected.

Since most manufacturers guarantee their motors to carry a 125 per cent load for periods of not longer than 2 hr. without overheating, and since this guarantee is made with some margin of safety, we could, no doubt, operate this motor under very favorable conditions at the stated loads without damage, but if the ventilation is poor or the power factor low a larger motor should be used.

In the last question, selecting an induction motor for variable speed makes our choice somewhat limited as there are few types of induction motors suitable for speed variation.

The wound motor or slipring motor and the B.T.A. motors are about the only ones, except some more recent additins to the motor market with which I have never had any experience.

The choice between the slipring and B.T.A. motors depends upon what per cent of full speed the motor will operate most of the time. If the motor must run at much less than full speed most of the time the B.T.A. will be the best as the slipring motor is very inefficient at less than full speed.

If, however, the motor can operate at or near full speed most of the time the slipring motor will be the best on account of its simplicity, giving it that advantage over the B.T.A. motor, which has both a commutator and sliprings, two rotor windings and the stator winding which, of course, would make maintenance costs somewhat higher on the B.T.A. motor.

Chicago, Ill. ROY M. STINSON.

Motor Drive for Isolated Machines

ON PAGE 183 in the February 15 issue there appeared a question in regard to the best type of induction motor for variable speed drive on isolated machines.

In my opinion, the "brush shifting" type is the best type of motor for this purpose. In addition to good speed control, it has the characteristics of good regulation and good starting torque.

This type of motor works on the counter e.m.f. principle of speed control, although its construction is quite different from the usual wound-rotor induction motor. It is built in intermediate sizes from 5 to 500 hp.

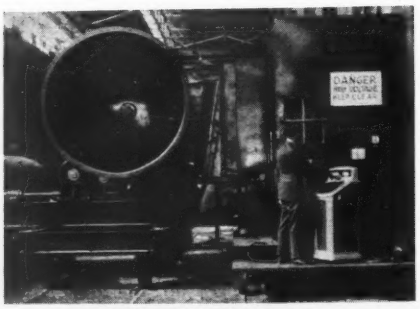
The input is through slip rings into the rotor and the stator winding represents the secondary. The rotor is also equipped with a separate winding connected to a commutator and two sets of brushes which can be rotated independently of each other. One brush from each set is connected to an end of the secondary or stator windings. When one set of the brushes is in line with the other on the same commutator bar, the secondary windings are short-circuited and the motor operates like the usual squirrel-cage type. If the brushes are separated, a difference in potential will be set up between the brushes, as generated in the special rotor winding. This voltage will be impressed on the stator as counter e.m.f. and will require the secondary to generate a voltage to balance it, which can be done only through reduced speed. The speed can be controlled then by brush shift, the characteristic which gives this type of motor its name.

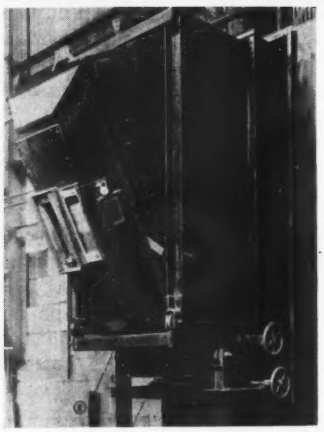
Bozeman, Montana. HAROLD M. HANSON.

New Equipment

X-Ray Inspection Outfit

In keeping with the notable advance in welding during the past year in the adoption of the new rules for welding unfired pressure vessels, St. John X-Ray Service Corp., has designed and installed equipment in various factories of which the latest is in the boiler shop of the Sun Ship Building & Dry Dock Co., Chester, Pa. While it is designed primarily for routine examination of welded boiler seams according to the code requirements, it can be used with facility for inspection of castings and other objects.





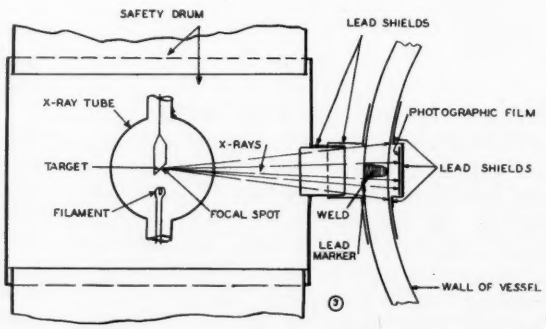


FIG. 1. ARRANGEMENT OF MOUNTING FOR BOILER SHELL AND X-RAY BOX
FIG. 2. TUBE BOX IS MOUNTED FOR TILTING AND TRANSVERSE MOTION
FIG. 3. SECTION OF TUBE WELD, FILM AND LEAD SHIELDS FOR INSPECTION OF BOILER SEAM

Flexibility and convenience have been secured by a coördinated system of supporting and rotating the boiler drums to be examined and of supporting and shifting the X-Ray tube. The vessels are supported on two sets of gear-driven rolls, each set mounted on a substantial truck, these trucks being movable along a track to accommodate boilers of different lengths or to clear protruding nozzles and manways. The roll-and-gear units are movable across the trucks to accommodate vessels of different diameter.

X-ray generator and tube are mounted on a car movable parallel to the boiler on a second track, as shown in Fig. 1. The X-ray tube is enclosed in a lead-lined box provided with an opening on the side toward the vessel, as in Fig. 2. This box is so mounted in trunnions that it can be tilted to direct the X-ray beam emerging through the window at any angle between 30 deg. below the horizontal and 30 deg. above. The trunnion frame is movable across the car to permit proper approach to a vessel only 2 ft. in diameter, or for proper clearance of nozzles protruding 2 ft. from a vessel 12 ft. in diameter. These motions are accomplished by two hand-wheels, one controlling the tilt, the other the transverse travel.

The X-ray car is moved along its track by a slow-speed electric drive controlled from a portable push-button station. The vessel on the tank stands is rotated by a worm-gear drive, which may be actuated manually or electrically.

Auxiliary lead shields between the X-ray box and the outer surface of the boiler drum are attached to the box itself and adjust themselves to the contour of the surface as the tube is moved into position, while similar auxiliary shields attached to the film carrier adjust themselves to the contour of the inner surface when the carrier is placed in position. This film carrier is moved along an adjustable rail for longitudinal seams or held by adjustable stops for girth seams and is removed only when passing from one seam to another. The exposure arrangement is schematically shown in Fig. 3.

Transformers for the X-ray tube and all high-voltage connections are enclosed within a metal housing on the X-ray car and, with the car itself, are thoroughly grounded through the rails. Adequate safety devices prevent entry to the high-voltage enclosure while the current is on.

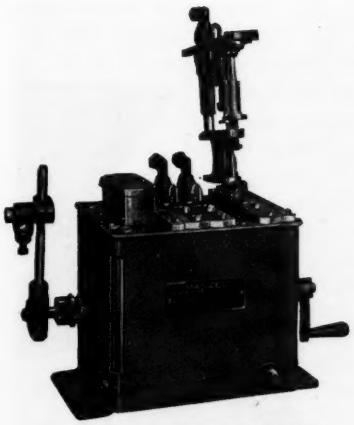
For examination of castings and miscellaneous articles, a special lead-covered booth is provided for the X-ray car near one end of the track.

Model 25 Lubricator

Model 25, Force Feed Lubricators are designed to deliver oil of any viscosity in accurately measured quantities against the high steam, gas and air pressures now so generally used on engines, pumps and compressors. This lubricator is built on the double plunger principle, with an individual pumping unit for each point to be lubricated. Working and moving parts are inside of the reservoir out of dust and dirt and constantly immersed in oil; any unit may be removed without stopping the lubricator or the equipment on which it is installed or, in the case of multiple feed lubricators, without interfering with other units. The discharge valves

are in separate cages independent of the pumping units and may be removed by simply unscrewing the cylinder outlet connection. Each pumping unit is independently adjustable and may be regulated at any time while the lubricator is in operation.

Sight feed, showing amount of oil delivered by each feed, is not under pressure and may be removed for cleaning or other purposes without interfering with the operation of the lubricator.



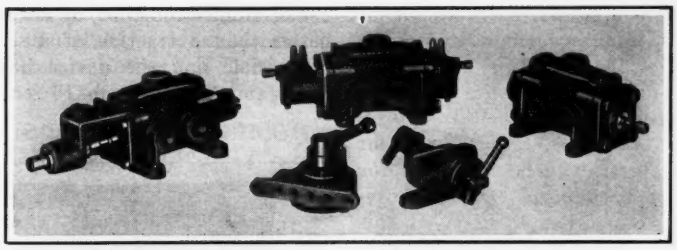
FORCE-FEED LUBRICATOR

Model "25" Lubricators can be furnished by Manzel Bros. Co., Buffalo, N. Y., with from one to thirty feeds, in any desired capacity, and with either ratchet, rotary or direct drive. Standard outlet fittings are for ¼ in. o. d. tubing, with 5/16 in. o. d. tubing, or ¼ in. or ⅛ in. iron pipe, fittings optional. For ammonia compressors the lubricators can be furnished with all steel and iron parts and double-compartment lubricators for feeding two kinds of oil can also be supplied.

4-Way Valves

VICKERS 4-way valves recently placed on the market are designed to be compact, conveniently applied to machine tools and other hydraulically operated equipment and for operating pressures up to 2000 lb. per sq. in.

Three types of valves are illustrated. At the left is the latch-controlled valve which makes one complete cycle and then stops; it is particularly adapted to press operations, hydraulically operated furnace installations, etc. The operator manually starts machine in one direction; at the end of the stroke a stop trips the latch and allows the internal spring to shift the valve to reverse position. When end of return is reached the machine is stopped by the valve.



SEVERAL TYPES OF VICKERS 4-WAY VALVES

The pilot operated 4-way valve with manual and mechanical pilot valves constitute the center group; it is designed to provide remote control without levers or links, and can be placed out of sight or wherever most convenient. It has simple external adjustments for controlling reversing speed. This feature is used to eliminate shock from rapidly moving tables. The manually operated 4-way valve is shown at the right. These valves are made by Vickers, Inc., Detroit, Mich.

Automatic Combustion Indicator-Recorder

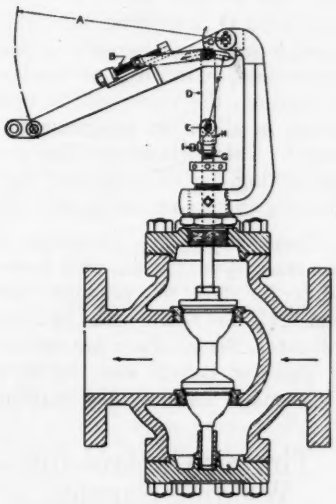
ALL METAL, automatic, flue gas analyzer known as the TAG-MONO Indicator - Recorder, has recently been placed on the market by The C. J. Tagliabue Mfg. Co. of Brooklyn, N. Y.

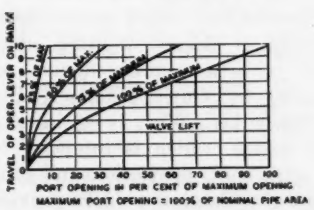
The instrument is designed not only to indicate and record the percent of CO_2 but also to give an accurate record of the percent of combustibles, such as $CO+H_2$, which may be present in the flue gas. The company states that this new instrument works on the orsat principle, analyzing chemically and indicating and recording electrically. The large illuminated dial and pointers are built to be easily seen at a distance of 30 ft., and in addition the records are made on a 9-in., 24-hr. circular chart with open graduations to permit precise study of the continuous performance curve.

DUPLEX INDICATOR-RECORDER

Lever Operated Control Valves

AS SHOWN in the illustration, these valves, made by Atlas Valve Co., Newark, N. J., have parabolic type, gradual-opening, bevel seats,





SECTIONAL VIEW AND PORT OPENING CURVES FOR ATLAS LEVER-OPERATED CONTROL VALVES

giving a progressive increment of port opening proportionate to the travel of the operating mechanism. Stroke of the lever where the control mechanism is attached is 10 in. on an arc whose radius is A but special levers can be furnished for control mechanisms whose movement is other than 10 in. With this stroke, the travel of the valve stem can be varied by moving the upper end of lever D to change radius C by means of screw B so that, for full stroke of the lever, valve port opening may be anything from 100 per cent of full opening to 8 per cent.

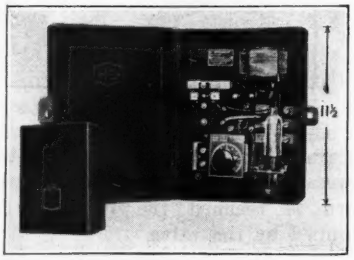
The valve is always closed when the lever is at its lowest point but the opening with lever at any point will vary as shown on the curves, depending on setting of lever D. Thus for a 4-in. valve full port opening would be 12.56 sq. in. At full lever stroke, the port would be open, for full valve lift setting 12.56 sq. in.; for half valve lift setting of D, 0.33 × 12.56 or 4.18 sq. in.; for ¼ valve lift setting, 1 sq. in. For half lever stroke, the corresponding port openings would be: For full valve lift, 0.325 × 12.56 = 4.07 sq. in.; for half valve lift, 0.08× 12.56 = 1 sq. in.; for ¼ valve lift, 0.03 × 12.56 = 0.38 sq. in.

Valves may also be set for minimum flow without use of a bypass. Valve stem G is screwed onto clevis H and locked by set screw I in position so that, with lever at the lowest position, the valve will be open enough to allow the minimum flow desired. This adjustment also permits setting the valve to close tight after regrinding or facing of seats.

These valves are furnished in sizes from ½-in. to 2-in. with bronze bodies for 300 lb. pressure, also from 2½ to 6-in. with cast-iron bodies for 250 lb. They are suitable for gases or liquids and can be of special metal where service requires.

Timing Control for Welding Service

AMONG THE MANY recent developments in electric welding equipment, a new timing device announced by Cutler-Hammer, Inc., of Milwaukee, Wis., is of interest. This device, which is intended for use with spot, projection and other forms of resistance welders provides extremely accurate timing control of the welding operation. By the use of an electron tube, an accuracy better than a fraction of a second is possible and the device has an adjustable range up to 16 seconds.

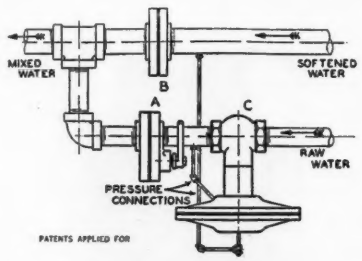


NEW CUTLER-HAMMER TUBE TIMING CONTROL FOR ELECTRIC WELDING

The timing is adjusted by a knob inside the enclosing case. It requires small mounting space and operates on 110 to 550 v. a.c. 25 to 60 cycles.

Automatic Softening Proportioner

TO ENSURE proper relation between treated and raw water the Elgin Automatic Proportioner automatically maintains definite proportions, regardless of changes of quantities or pressures of raw water and treated supply. The equipment consists of a calibrated orifice valve A and a reducing valve C working upon the diaphragm principle, both connected in the raw water line.



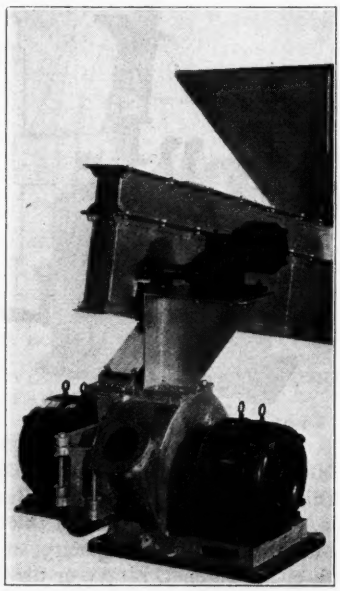
ELGIN AUTOMATIC PROPORTIONER FOR WATER TREATMENT SYSTEMS

Functioning of the reducing valve is controlled by the pressures in the soft water and the hard water lines. By employing orifices of the correct proportionate areas at A and B, the desired proportion of flow may be readily obtained, by the setting of the single special orifice valve and regardless of changes in initial pressures or quantities.

When it is desired to change the proportion of hard to soft water, the handle of the adjustable orifice valve A is set at the position corresponding to the desired proportion as indicated by numbers cast upon the body of the valve, table showing the proportions corresponding to these numbers.

Pulverized Coal Unit

IN THIS UNIT, provision is made for grinding to a fineness of 85 per cent through 200 mesh and firing any number of boilers up to the capacity of the unit. It can be arranged to operate by control of pressure or temperature switches. Sizes run from 7-in. with capacity of 10 to 50 lb. of coal an hour to 18-in. for 600 to 1500 lb. an hour. Larger sizes can be built up to 25 t. an hour. It is made by Holbeck Direct-Firing Unit Corp., Cleveland, Ohio.



HOLBECK PULVERIZER AND FEEDER FOR SMALL BOILER UNITS

IOWA state board of railroad commissioners is arranging for a hearing in Des Moines upon five transmission line project petitions. The Iowa-Nebraska Light and Power Co., Lincoln, Neb., is seeking extensions in Fremont, Pottawattamie, Adams and Taylor Counties, totaling 31 mi.; the Iowa Public Service Co., Sioux City, 1.25-mi. extension in Woodbury County and Clay County board of supervisors 2.5 mi. in that county.

Magnetic Friction Clutch

IN A SMALL, powerful clutch Dings Magnetic Separator Co. provides contact faces on both sides of a spring disc which are squeezed between the magnet and armature elements when the coil is energized, giving power transmission theoretically double that of single contact face but actually of approximately 75 per cent greater torque.

Provision is made for adjustment to compensate for wear and light springs serve to separate contact faces when not working, thus assuring ample clearance between the clutch elements. A single-spring disc clutch follows the same general construction but has three friction faces with consequent increased torque and power transmission. Housing completely protects the slip ring brush holder assembly. Friction wearing faces are durable asbestos compound formed to fit and riveted to the clutch disc. Common installation is to mount the magnet element on the driving shaft and disc element as the driven member but it is perfectly feasible to reverse the clutch mounting.

George P. Torrence Heads Link-Belt Co.

GEORGE PAULL TORRENCE, vice president in charge of the company's Indianapolis operations, has been elected president of Link-Belt Co., Chicago, Ill. With 21 years' experience in various departments of the company which he now heads, he is now responsible for the management of the company's plants, warehouses and sales organization.

Following graduation from Purdue University in 1908, Mr. Torrence spent a year in Arkansas with the Ayer & Lord Tie Co., then a two-year shop apprentice course in the Pittsburgh shops of Westinghouse Air Brake Co., following which he entered the employ of Link-Belt Co. in Indianapolis, as a sales engineer. In 1915 he was placed in charge of merchandise and chain sales in the company's western division, with headquarters

in Chicago, returning in 1920 to Indianapolis as sales manager of the Ewart Works. In 1925 he was made general manager of both the Dodge and Ewart Plants; and in 1928 vice president of the company, with headquarters in Indianapolis.

News From the Field

UNITED ELECTRIC LIGHT & POWER CO. of New York has just ordered three large Taylor stokers from the American Engineering Co., Philadelphia, for installation in the Hell Gate Power Station in New York City, work to start April 1 and be completed by September 1.

WORTHINGTON PUMP AND MACHINERY CORP., Harrison, N. J., has appointed Frank R. Wheeler special sales representative with headquarters at its Chicago office. He will cover the mid-west territory, assisting the Worthington organizations in Chicago, St. Paul, Kansas City, St. Louis and Detroit. Mr. Wheeler, who has done much work in connection with steam power plants, will devote himself to the sale of Worthington products in that field.

BABCOCK & WILCOX TUBE CO., Beaver Falls, Pa., announces the opening of a new branch office, in the Ford Building, Detroit, Mich. J. E. Polhemus has been appointed District Sales Manager, in charge of the Detroit territory. Mr. Polhemus was formerly assistant vice-president and district sales manager of the Detroit sales branch of the Associated Alloy Steel Co.

D. H. SKEEN & CO., Chicago, Ill., is now distributor for that territory for the products of Tube Turns, Inc., of Louisville, Ky.

MCCLAVE-BROOKS CO., Scranton, Pa., announces the appointment of the Proctor Engineering Co., Inc., 28 So. Gay St., Baltimore, Md., as its exclusive sales representatives for concentration of sales and service in the states of Maryland, Virginia and the District of Columbia.

K. G. FRANK, 75 West St., New York, N. Y., representative for Siemens-Schuckertwerke, A. G., states that the Siemens Review will in the future be published quarterly instead of monthly. Issue No. 1 is scheduled for publication in March and future numbers will be available at the end of each quarter.

CAREY MACHINERY & SUPPLY CO., 119 E. Lombard St., Baltimore, Md., has been appointed distributor for Gears and Forgings, Inc., of Cleveland, Ohio.

JOHN T. CLANCY, an executive of Worthington Pump and Machinery Corp., died suddenly of a heart attack, March 9, while lecturing at the Engineers' Club, New York City, before a meeting of the American Society of Mechanical Engineers. Mr. Clancy was born in New Brunswick, N. J., in 1890. After attending the New Brunswick schools, he studied at Betts Academy, Stamford, Conn., and later at Bowdoin College where he was graduated in 1913, and at Catholic University. He became an instructor in mathematics and chemistry at the Army & Navy School, Washington, D. C., and in 1917 he entered the Army, serving overseas as captain of field artillery with the A.E.F. In 1919 he joined the Worthington Pump and Machinery Corp., and in 1923 became assistant manager of oil and gas engine sales, with headquarters at Buffalo, N. Y., the position he had held until his death. In July, 1931, his headquarters were moved to the Harrison, N. J., plant.

MORSE CHAIN CO., Ithaca, N. Y., division of Borg-Warner Corp., has been appointed exclusive sales agent for Morse Pullmore Clutches, made by the Rockford Drilling Machine Co., Rockford, Ill.

TILE FOR VERTICAL baffles in water-tube boilers, with lapping vertical joints and tongue-and-groove horizontal joints laid in fire clay batter are announced by the Power Plant Efficiency Co., Indianapolis, Ind. The construction gives a baffle with irregular vertical surface, due to leaning of the tile against the tubes for support, thus producing a swirling motion of the gases in their upward travel which is claimed to be desirable in aiding combustion and heat transmission.

GOULDS PUMPS, INC., has removed its Chicago office to 35 E. Wacker Drive, Telephones Franklin 4612-3, warehouse being maintained at 217 No. Jefferson St.

WARD LEONARD ELECTRIC CO., has established a Chicago office at 53 W. Jackson Blvd., in charge of Kline Gray as district manager.

KENNEDY VALVE MANUFACTURING CO. announces the removal of its Chicago branch office and warehouse to larger quarters at 1306-1312 South Canal St. in the Soo Terminal.

JOSEPH F. BECKER, sales manager of the United Electric Light and Power Co., has been elected vice-president in charge of sales of The New York Edison and the United companies. Mr. Becker has been sales manager of the United company since 1909, when he was transferred to that company from the Brooklyn Edison Co., where he had served successively as meter clerk, superintendent of the Meter Department and general sales agent since 1890. He is a director of the Brooklyn Edison Co. He was educated at the Trade Schools of the Polytechnic Institute and Pratt Institute, Brooklyn.

ACQUISITION by Alco Products, Inc., a division of the American Locomotive Co. with headquarters in New York City, of the business, good will, patents and essential personnel of the Jackson Engineering Corp. of Tulsa, Okla., on March 1 has been announced. Gordon M. Jackson, former president of the Jackson company, has become Alco sales manager. The technical men are continuing under the direction of Karl Finsterbusch, former chief process engineer of the Jackson company, with Paul D. Barton as consulting engineer. The former Jackson field engineers will continue with Alco in their former locations.

For the Engineer's Library

MUNICIPALLY OWNED ELECTRIC UTILITIES IN NEBRASKA, by Paul J. Raver and Marion R. Sumner, is a 61-page paperbound book published by the Institute of Economic Research of Northwestern University, reviewing the changes in number, type and power of municipal plants from 1887 to 1931 and discussing the factors which have influenced those changes. The price is $1.50 and the address of the Institute is 337 East Chicago Ave., Chicago, Ill.

Complete data are given as to individual plants, their establishment to supply service where no private company was operating or in competition, swing of plants to purchasing and distributing of current, absorption of municipal plants by private systems, relative and absolute growth in number and in horsepower capacity of private and municipal plants and variation of motive power in municipal plants. While the number of municipal plants has decreased materially since 1926, the horsepower capacity has increased. From 1919 plants of 100 hp. and under show rapid decrease; plants of 100 to 200 hp. have decreased steadily since 1925; plants of 200 to 500 hp. have shown some increase, while plants of 500 hp. and over have increased quite rapidly since 1923. The increase in total horsepower has been largely from expansion of the larger plants.

As to type of motive power, gas engines and steam engines have practically disappeared. Oil engine plants have fallen off slightly in number since 1921 but their total horsepower has been largely increased. They are now three times as numerous as all other types combined. But the few steam turbine stations, five in all, have combined capacity 50 per cent greater than all the oil engine stations. Also, no steam-turbine plant has passed from municipal to private ownership and all of them are in the 500-hp. or over class.

As private transmission lines have spread, small municipal plants have either purchased power or passed to private ownership, while the larger and more economical plants have held their own and expanded with the growth of the communities served.

Chapters in the book discuss the legal provisions affecting municipal plants, reasons for changes of ownership and give a summary of the municipal ownership movement in the state.

GENERAL ENGINEERING HANDBOOK. Editor-in-chief, Charles Edward O'Rourke. First Edition, size 5 by 8 in. Red Fabrikoid, 922 pages, illustrated. McGraw-Hill Book Co., Inc., New York, 1932; price, $4.00.

It is always difficult to write a review of a handbook such as this, for the very magnitude of the work makes it impossible to present even an outline of what it contains. The plan for this handbook according to the editor-in-chief, who is Assistant Professor of Structural Engineering at Cornell University, was conceived in the belief that a great amount of fundamental engineering data could be assembled in a compact pocket book of not over 900 pages, which would be valuable as a ready reference and hand companion for practicing engineers and students. The purpose is not to supplant the detailed and voluminous handbooks devoted to special branches of engineering but to supply a compact reference work of important fundamentals for all engineers.

This, it seems to us, has been accomplished in a most satisfactory manner. The book is divided into 31 sections of varying length, each section dealing with one general subject. Six of these sections contain material which is of importance to all engineers; eleven belong primarily to the field of civil engineering; nine to mechanical engineering and five in electrical engineering.

It has been assumed that the users of the book are familiar with general engineering theory and practice and have a fundamental knowledge of the use of ordinary equations, diagrams, tables, charts and other common methods of presenting facts and coordinating functions.

The handbook is replete with tables and charts covering all the important materials and functions used in all the various branches of engineering. In order to incorporate all the desirable reference material in a single small volume, it has been necessary to reduce to an absolute minimum, general descriptive matter, historical facts, highly specialized material, derivation of formulas, etc. A bibliography of the more important works dealing with the subject, is included at the end of each section. The book is of convenient size, the format is excellent and there is a good index.

HOW SHALL WE HANDLE IT? is the title of an illustrated letter-size bulletin just published by the Diamond Rubber Co., Inc., Akron, Ohio. This discusses the handling of coal, concrete, metals, sand, gravel, plaster and raw materials in general, also parts and packages, by belt conveyor, showing by photographs applications of belt conveyors in 27 different industries.

TESTS of Plain and Reinforced Concrete Made with Haydite Aggregates, by Frank E. Richart and Vernon P. Jensen, has just been issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill., as Bulletin 237. New structural problems have come into being through the ever increasing length of bridge spans and height of buildings and through frequent necessity of adding to existing structures. The solution of these problems has led to the development of numerous light-weight concretes, some of these being obtained by the use of light-weight aggregates. The investigation was made to secure information regarding one of these materials, Haydite, and the work was further limited to a study of the structural properties of poured Haydite concrete as distinguished from the dry Haydite mixtures used in the manufacture of concrete building blocks, tile, pipe and other pre-cast units. Haydite is the material produced by burning shale in a rotary kiln to the point of incipient fusion, whereupon the oxidation of its carbon content forms gases and causes the material to expand into a light-weight cellular clinker. This clinker is crushed and screened to produce the gradations desired for concrete making.

The investigation was planned to secure information as to the desirable proportions of mixture to produce a given weight, strength and workability, as well as data on the elastic properties of the material and on its action in structural members. Throughout the investigation the tests of Haydite concrete were paralleled by tests of sand and gravel concrete, to furnish comparisons of the properties found and to give an idea of the uniformity of the materials, test methods and workmanship employed.

Copies of the bulletin may be obtained without charge from the Station.

BULLETIN No. 235, An Investigation of the Suitability of Soy Bean Oil for Core Oil, by Carl H. Casberg and Carl E. Schubert, has just been issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. Since soy bean oil has been used by some manufacturers as a diluent for core oils, it was suggested that an investigation be undertaken in order to determine the suitability of soy bean oil either as a substitute for, or a diluent of, other oils used for the purpose of making cores.

PRECISION PRESSURE CONTROLLERS are described and illustrated in a letter-size, 16-page bulletin, No. 401, just published by Mason Regulator Co., 1190 Adams St., Boston, Mass. Explanation of the operating principle is given and details of the controllers are discussed. They are made in recording and non-recording types.

WETKROME, a wet, ready-mixed, ready-to-use chrome ore cement, is described by E. J. Lavino & Co., Bullitt Bldg., Philadelphia, Pa., in new Bulletin 1-21-1.

CONSTANT PRESSURE REGULATORS for valve control, electrically actuated, are completely described and illustrated in Bulletin CP-3 just published by Brooke Engineering Co., Inc., 3640 W. Lawrence St., Philadelphia, Pa. Bulletin S-3, just issued, describes regulators for boiler control.

How to Run a Lathe, thirtieth edition, 1932, 6 by 9 in., 160 pages, illustrated, by J. J. O'Brien and M. W. O'Brien, South Bend Lathe Works, South Bend, Ind.; price, 25 cents.

Prepared as an authoritative manual on the care and operation of a modern screw-cutting lathe, this book will be found helpful to power plant engineers who supervise their own repair work. It contains step by step instructions aided by working drawings covering single jobs which are most easily done on a lathe. A thorough index makes the information in the book readily available.

Wagner Electric Corporation, St. Louis, Mo., has issued a new 22-page bulletin on squirrel-cage motors, Bulletin 174. The bulletin describes the seven types of squirrel-cage motors, gives application tables, speed-torque curves, complete construction details. It is in loose-leaf form to permit keeping it up to date at all times.

Republic CO_2 Meters are described and fully illustrated, their principle of action explained and much data on combustion problems given, including a list of causes of inefficient combustion and table of preventable losses, in a handsome 24-page catalog, No. 401, issued by the Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill., who will be glad to send a copy in response to written request.

New developments in unburned magnesite brick for the metallurgical industry are discussed in a recent bulletin by General Refractories Co., 106 So. 16th St., Philadelphia, Pa. This includes an article on the subject by A. E. Fitzgerald, ceramic engineer of the company.

The one stoker for any coal is the title of Bulletin No. 101 just published by Joseph Harrington Co., a subsidiary of the Whiting Corp., Harvey, Ill. It discusses the operation of these stokers with various types of coal, gives test data, describes their construction features and details about the various models.

Indicating and recording gages, featuring pointer gages for draft, pressure, differentials and temperature are described and illustrated in detail by Catalog No. PGA-32 just issued by the Hays Corp., Michigan City, Ind. Detailed description of the operating mechanism is given, accompanied by tables showing pressure and draft ranges for which they are designed; also tables and drawings of dimensions and photographs of applications.

Mercon Regulator, its operating principle, details of the working parts and data on selecting size of regulator and methods of installation are given in Catalog No. 5, just published by the Mercon Regulator Co., 1 La Salle St., Chicago, Ill.

What 100 Representative Cities Pay For Electric Light and Power under Municipal Ownership is the subject of a 60-page bulletin recently published by Burns & McDonnell Engineering Co., consulting engineers, Interstate Bldg., Kansas City, Mo., price $1.00. The data in this book, compiled by C. F. Lambert of the company, includes comparisons of monthly costs, charges for services, tables of output, type of power, revenues, expenses, gross profits and valuations and the object of the book is to present as fair a cross section as possible of what municipalities are doing toward solving their power problems. The majority of the plants listed are steam, a number are Diesel plants, some are a combination of steam and Diesel and a few are hydroelectric plants.

Propeller Fans for general ventilation purposes in industries, offices, institutions and homes are completely described and their applications illustrated in a new 48-page, letter-size bulletin published by Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, Ill. The bulletin also describes the power roof ventilator and a variety of devices for domestic use.

Filtered Air—Its Importance in Building Ventilation and Air Conditioning is discussed in detail in a new illustrated bulletin published by the American Air Filter Co., Louisville, Ky. This contains data on the dirt content of air and on applications of filters to remove this dirt.

In technical bulletin No. 271, just issued by the United States Department of Agriculture, Washington, D. C., Carl Rohwer, associate irrigation engineer, Bureau of Agricultural Engineering, discusses evaporation from free water surfaces. This bulletin is for sale by the Superintendent of Documents, Washington, D. C., price $0.25. Mr. Rohwer begins with a discussion of evaporation formulas developed by previous investigators, then takes up still-air observations, effect of temperature on evaporation equipment, observations with controlled wind under laboratory conditions, observations outside, evaporation from ice under controlled conditions in the laboratory, effect of altitude, influence of size of tank and various observations and computations with suggestions regarding evaporation observations. The conclusions are summarized and a bibliography on the entire subject is given.

Special Equipment for the process industries, fabricated from steel and alloy metals, is the subject of Bulletin No. 71 just published by the Edge Moor Iron Co., Edge Moor, Del. It describes the service the company is prepared to offer for the fabrication of special equipment involving problems of heat, corrosion and contamination resistance. It shows the shop facilities available for the handling of equipment as well as examples of completed projects and designs for various unusual services.

Electric weld line pipe and casing are described in an attractively-colored and artistic 36-page bulletin just issued by the Republic Steel Corp., Youngstown, Ohio. The bulletin discusses the manufacture of this pipe, shows the joints for which it can be supplied, discusses the advantages and presents test data and tables of safe working pressures. Data on electric weld casing are given at the end of the bulletin.

Pullmore Clutch, its principle, details of construction and methods of application, are completely described and illustrated in a new 12-page bulletin issued by Morse Chain Co., Ithaca, N. Y.

Forced draft spray cooling towers, their construction, operation and applications, are described in detail in a new bulletin issued by the Marley Co., 1737 Walnut St., Kansas City, Mo.

Arc welders, gasoline engine driven, in sizes from 200 to 600-amp. are described in bulletin GEA-1543, just issued by the General Electric Co., Schenectady, N. Y. They are designed especially to meet the severe requirements of pipe line welding and the catalog describes their construction in detail. In Bulletin GEA-1480A, superseding 1480, the company describes the new General Electric photoelectric recorder, designed to permit the recording of any measurable quantity accurately. In this recorder a mirror in the galvanometer system reflects a beam of light into two photoelectric tubes, the output of which is amplified to supply power for operating a high torque electric recording element. The instrument is designed to record quantities that could not previously be recorded except in the laboratory and, in fact, any quantity that can be measured, such as current in microamperes, voltage in millivolts, frequency in hundredths of a cycle, thickness of sheet metal, diameter of ball bearings, high temperatures and the like.

Centrifugal compressors, Design 9, are described in Bulletin 386 just issued by B. F. Sturtevant Co., Hyde Park, Boston, Mass. Details of the compressor construction are given with tables of volumes, motor ratings, dimensions and performance curves. In another new catalog, No. 370, the company describes convertible multivane fans. Details of construction, tables of dimensions and tables of capacities and pressure are given in the bulletin.

Use of the Maihak indicator for detecting poor compression in Diesel engine cylinders is discussed in detail in a recent bulletin, No. 3266, by Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Bulletin No. 112, describing Bailey boiler water level recorders has just been published by the Bailey Meter Co., Cleveland, Ohio. This booklet, printed in two colors, outlines the advantages, the mechanical construction, and various methods of installation of the recorder. It describes the method for obtaining records of the true water level throughout the full range of the drum. Illustrations showing installations and reproductions of actual chart records.

Model 25 Force Feed Lubricators for positive and automatic lubrication of cylinders and bearings, as described on page 353 of this issue of Power Plant Engineering, are discussed in greater detail in catalog No. 31 recently issued by their manufacturer, Manzel Brothers Co., Buffalo, N. Y.

Recording Absolute Pressure Gage, direct reading type, is completely described in Catalog No. 1011 just issued by The Bristol Co., Waterbury, Conn. It is designed for use not only with turbine and engine condensers but also with many industrial processes employing vacuum pans, vacuum stills, in packing and sealing foods and others. The instrument can be furnished for ranges as low as from 0 to 50 mm. head of mercury pressure absolute.

Field Barometric Draft Control, designed to prevent heat loss from fluctuating draft, to aid in reducing boiler outlet gas temperatures and built for any stack, is described in detail in a well-illustrated, letter-size 28-page bulletin just published by Field Sales Corp., 5510 Broadway, Chicago, Ill. Test data from a large number of installations are given to show savings obtained by its use.

Power Plant Construction News

Ariz., Mesa—Independent Cotton Oil Co., Mesa, is said to be planning installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss estimated at $70,000.

Ariz., Salome—Anozira Mining & Milling Co., 124 West Fourth Street, Los Angeles, Calif., plans installation of electric power equipment in proposed new milling and concentrating plant at copper properties about 40 miles from Salome. Entire project estimated to cost close to $500,000.

Alta., Raymond — British Columbia Sugar Refining Co., plans installation of electric power equipment in proposed new addition to local beet sugar mill, including improvements in machinery in present unit, entire project to cost over $200,000.

Conn., Mystic—Mystic Ice Co., Mystic, has filed plans for a one-story ice-manufacturing plant, to be equipped for an initial capacity of 20 tons per day. Frank Bergman is general manager.

Conn., New Britain—The Spring Brook Ice Co., 17 Spring Street, E. Doerr, general manager, is considering construction of a new ice-manufacturing plant, reported to cost over $25,000, with machinery.

Conn., Rockville—Alfred Ludwig, Rockville, is at the head of a project to construct and operate an ice-manufacturing plant on Armour property, Brooklyn Street, reported to cost over $24,000, with machinery. It is expected to have unit ready for service in June.

Fla., Tampa—Beecroft Studios, Inc., Tampa, will install electric power equipment in new sound motion picture producing plant on Davis Island, where existing structure has been secured, to be remodeled and equipped at once. Estimated cost $100,000.

Ill., Niles Center— Phillips Petroleum Co., Bartlesville, Okla., plans installation of power and pumping equipment, tanks, etc., in new oil storage and distributing plant at Niles Center, estimated to cost $100,000. General building contract has been let to Austin Co., 510 North Dearborn Street, Chicago, Ill.

Iowa, Ottumwa—Board of Waterworks Trustees, Horace A. Brown, waterworks superintendent, has plans under way for a water-softening plant for municipal water service, estimated to cost about $200,000, with equipment.

Mass., Boston—Trimount Dredging Co., 10 State Street, is said to be planning early replacement of floating power plant, used for furnishing service for dredging operations, recently destroyed by fire while operating in Charles River. Loss estimated over $80,000.

Minn., Albert Lea—City Council has authorized a survey and estimates of cost for installation of a natural gas distributing system. Black & Veatch, Mutual Building, Kansas City, Mo., are consulting engineers.

Minn., Rochester—City Council, Rochester, plans installation of pumping machinery and auxiliary equipment in proposed sewage treatment plant, entire project to cost about $175,000. It is expected to ask bids in spring. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Minn., Winona—Water and Light Board, City Council, has plans under way for extensions and improvements in municipal pumping plant for water service. Bids will soon be asked. E. E. Chadwick is city engineer.

Mo., Cape Girardeau—Pure Ice Co., 314 South Ellis Street, has approved plans for a one-story addition to ice plant, reported to cost over $24,000, with equipment. Jules Reither, Cape Girardeau, is architect.

Neb., St. Edward—Common Council, St. Edward, is having estimates of cost made for a proposed municipal electric light and power plant. It is expected to proceed with project at early date. City clerk, in charge.

N. Y., New York—Department of Sanitation, Municipal Building, plans installation of electric power equipment, mechanical-handling machinery, unloading, equipment in four new garbage incinerator plants, for which sites are being selected, each estimated to cost $962,000, totaling $3,848,000 for project.

N. Y., New York—Interborough Rapid Transit Co., 165 Broadway, will make extensions in power stations and facilities to cost $540,000, including installation of additional equipment. Company will also install signal apparatus on center tracks of Queens lines to cost $250,000. Work has been authorized by the City Transit Commission, 270 Madison Avenue, New York.

N. Y., Union Hill—Union Hill Canning Co., Union Hill, plans installation of electric power equipment in connection with proposed rebuilding of portion of food products canning plant, recently destroyed by fire with loss reported at $50,000.

Ohio, Columbus—Columbus Railway, Power & Light Co., North Front Street, has taken out a permit for a two-story addition to power substation on Cleveland Avenue, 28 x 109 ft., including improvements in present plant, estimated to cost over $75,000, with equipment. Engineering department is in charge.

Ohio, Piqua—City Council, Piqua, is arranging early call for bids for a municipal electric light and power plant, including turbo-generator unit, boiler and accessories, surface condenser, exhaust fans, pumping machinery and complete auxiliary equipment. Entire cost estimated at $810,000. Court action against project has recently been settled in favor of city. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Ohio, Wellsville—City Council has authorized employment of engineer and estimates of cost for proposed extensions and improvements in pumping plant for municipal water service, including electrification of station. Service-Safety Director will be in charge.

Pa., Brodheadsville—National Portland Cement Co., Finance Building, Philadelphia, Pa., recently organized with Robert H. Anderson as president, plans construction of power house at proposed new cement mill in vicinity of Brodheadsville, Northampton County, in addition to electric power equipment in mill. Entire project reported to cost over $1,500,000. Fred B. Franks, Sr., vice-president and general manager, will be in charge of construction.

Pa., Greenville—Greenville Steel Car Co., Greenville, plans installation of electric power equipment in connection with proposed rebuilding of machine shop, recently destroyed by fire, with loss estimated at $50,000.

Que., Montreal—Joseph Elie, Ltd., Montreal, oil products, plans installation of electric power equipment in proposed oil refining plant on Sherbrooke Street East, near city limits, where site has been acquired. It is planned to build a boiler house and pumping station. Entire project is estimated to cost over $600,000.

R. I., Newport—Bureau of Supplies and Accounts, Navy Department, Washington, D. C., will receive bids until March 22, for one motor-driven centrifugal pump, as per Schedule 7696, for Newport Navy Yard.

S. C., Chester—Eureka Cotton Mill, Chester, plans installation of electric power equipment in three new one and two-story plant units, entire project reported to cost over $100,000.

Tenn., Maryville—City Commission, Maryville, is said to be considering construction of a municipal electric light and power plant. Estimates of cost will soon be made.

Tenn., Philadelphia — Philadelphia Hosiery Mills, Philadelphia, plan installation of electric power equipment in new two-story addition, to be used for box manufacture and other service, reported to cost over $45,000, with other plant improvements. E. W. Waller is secretary and treasurer.

Texas, Muenster—Common Council has asked proposals for equipment for a water supply system, including 50,000-gal. elevated steel tank and accessories. Montgomery & Ward, Wichita Falls, Texas, are engineers.

W. Va., North Fork—North Fork Water Co., North Fork, plans rebuilding of pumping plant, recently destroyed by fire. Official estimate of loss not announced. Appalachian Electric Power Co., Bluefield, W. Va., plans replacing of damage at North Fork power substation, caused by same fire.

W. Va., Wheeling—Wheeling Coal Co., Wheeling, is planning rebuilding of tipple and other portion of mining structures at coal properties, recently destroyed by fire, with loss estimated at $70,000.

Wis., Green Bay—City Council, Green Bay, is having plans prepared for electrification of municipal pumping plant, with installation of two 1500-gal. per min. pumping units, and one pump of 1000 gals. per min. rating. J. S. Hartt, 122 West Washington Avenue, Madison, Wis., is engineer.